GEOLOGICAL SURVEY BRANCH
DEPARTMENT OF MINES AND ENERGY
GOVERNMENT OF NEWFOUNDLAND AND LABRADOR

REPORT OF ACTIVITIES

1990

St. John's, Newfoundland
1990

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Compiled by
C.P.G. Pereira

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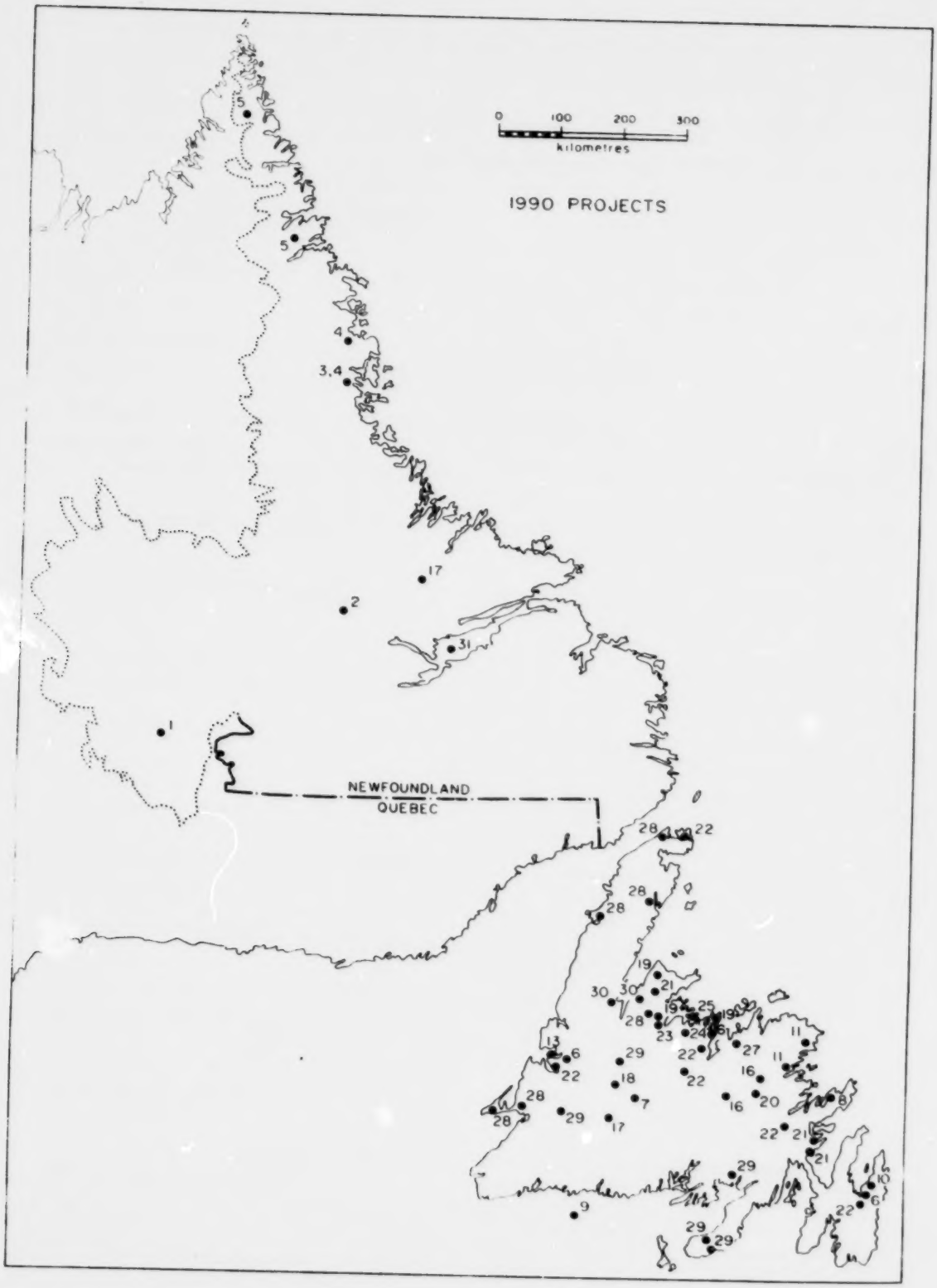
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1990 PROJECTS
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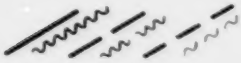
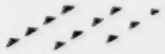
GEOLOGICAL MAP SYMBOLS

Geological contact (defined, approximate, assumed, gradational)

Fault (defined, approximate, assumed)



Thrust fault (defined, approximate, assumed)



Zone of numerous imbricate thrust faults

Bedding, tops known (horizontal, inclined, vertical, overturned)

Bedding, tops unknown (horizontal, inclined, vertical, dip unknown)

Pillow bedding, tops known (inclined, vertical)

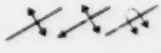
Flow banding (inclined, vertical)

Fracture cleavage (inclined, vertical)

Syncline, showing direction of plunge (defined, approximate)

Anticline, showing direction of plunge (defined, approximate)

Antiform (horizontal, plunging, overturned)



Synform (horizontal, plunging, overturned)

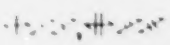
Minor fold axis (with plunge)

S folds, Z folds

Gneissic foliation (horizontal, inclined, vertical, dip unknown)

Schistosity, cleavage, foliation (horizontal, inclined, vertical)

S_1, S_2



Foliation due to thrusting (inclined, vertical)

Lineation, fold axis, mineral rodding

Jointing (horizontal, inclined, vertical)

Primary igneous layering (inclined)

Shear zone (approximate)

Alteration zone

Unconformity

Contact inferred from magnetic anomaly

Glacial striae

Drift covered area

Topographic lineaments from aerial photographs

Road

Power transmission line

Mine Pb

Mineral Occurrence Zn

Location of measured section

Abbreviations

Arsenopyrite	asp	Iron formation	i-f
Asbestos	asb	Magnetite	mag
Chalcopyrite	cp	Molybdenite	mo
Copper staining	cs	Pyrite	py
Fluorite	fl	Pyrrhotite	po
Galena	gn	Radioactive minerals	ra
Hematite	hem	Serpentine	sup
		Sphalerite	sp

Chemical symbols are used for elements, e.g. Cu..... copper

LABRADOR MAPPING SECTION

PRELIMINARY REPORT ON GEOLOGICAL MAPPING IN THE OSSOKMANUAN LAKE - LAC JOSEPH AREA, GRENVILLE PROVINCE, WESTERN LABRADOR

D.T. James, D.G. Dunphy and D.M. Stephenson
Labrador Mapping Section

The 1990 field season involved systematic geological mapping of the southwest corner of the Ossokmanuan Lake map area (NTS 23H, including H/3, H/4, H/5 and H/6) and, the northwest corner of the Lac Joseph map area (NTS 23A, including A/11, A/12, A/13 and A/14). Mapping was mainly helicopter-supported and carried out from a base camp on the currently-under-construction Labrador City - Churchill Falls section of the Trans-Labrador Highway. Outcrop exposure is varied from relatively good in the northern part of the map area, to very poor in the southern part.

The map area (Figure 1) contains parts of the Churchill Falls Terrane (lower structural-deck) and the Lac Joseph Terrane (upper structural-deck). These tectonically juxtaposed terranes consist of mainly ca. 1.67-1.62 Ga crust and occur adjacent to the northern margin of, and within, the Grenville Province of western Labrador. The area has been affected by two orogenic events: the ca. 1.7-1.6 Ga Labradorian Orogeny and the ca. 1.0 Ga Grenville Orogeny.

LAC JOSEPH TERRANE (LJT)

The LJT forms the upper structural-deck and consists of high-grade supracrustal rocks, granitoid gneisses, gabbronorite - gabbro and granitoid intrusive rocks. The high-grade supracrustal rocks are mainly quartzofeldspathic paragneisses having a minor amount of mafic supracrustal gneiss. The paragneisses are migmatitic with two leucosomes and commonly contain the assemblage: K-feldspar - biotite - sillimanite - garnet - magnetite, rarely, the paragneisses contain orthopyroxene. Locally, the paragneisses contain lenses of high-grade mafic gneiss that are the presumed relics of deformed mafic dykes.

Granitoid gneisses in the LJT occur in a body of uncertain dimension in the central part of the terrane and also as scattered occurrences throughout the southern part of the map area. These rocks are lithologically similar to occurrences of granitoid gneisses that form part of the Trans-Labrador batholith, in the Churchill Falls Terrane.

The supracrustal rocks are intruded by large bodies and dykes/sills of gabbronorite - gabbro that are variably deformed and recrystallized. Deformation and concomitant recrystallization appear to have occurred at granulite-facies conditions. Locally, cumulate layering in the gabbronorite bodies and syn-high-grade, high-strain fabrics (presumed Labradorian structures), as well as the migmatitic layering in the paragneisses, are cut by undeformed gabbro dykes that have been recrystallized under high-grade conditions.

Dykes and small bodies of granitoid intrusive rocks intrude both the supracrustal rocks and the gabbronoritic - gabbroic rocks. Occurrences of alkali-feldspar megacrystic granite, locally rapakivi-textured, and occurrences of quartz monzonite - monzodiorite are foliated and recrystallized to varied degrees. This is in contrast to a body of quartz syenite that occurs in the southwest part of the map area, which is non-foliated and has a phaneritic texture. The structure and texture of the quartz syenite suggests that it is the youngest unit in the LJT, however the relative ages of the granitoid units are equivocal because of the very limited number of exposures.

Internally, the structure of the LJT is characterised by north-northwesterly- to north-northeasterly-striking foliations and traces of

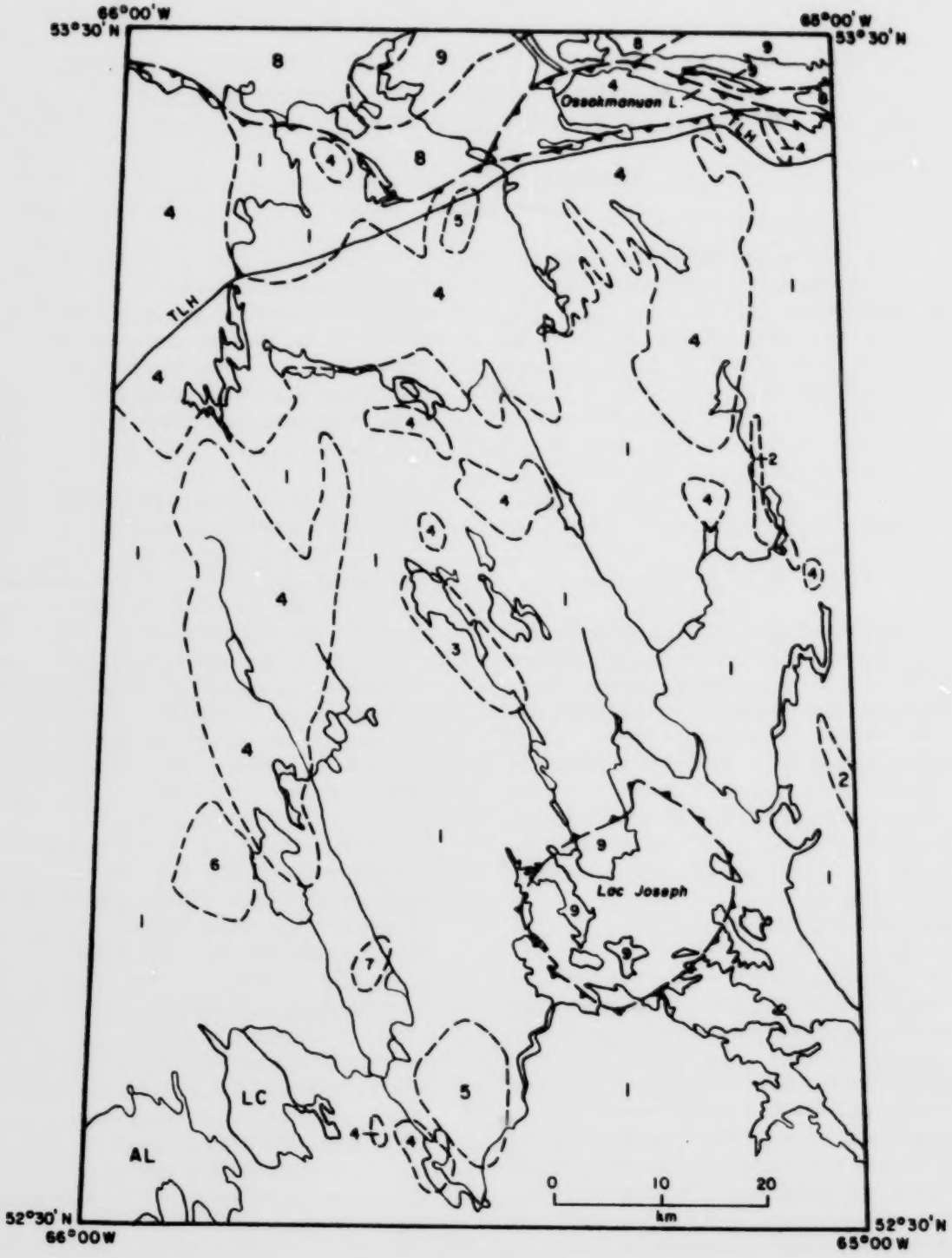


Figure 1. General geology of parts of the Ossokmanuan Lake (23H) and Lac Joseph (23A) map sheets.

LEGEND

CHURCHILL FALLS TERRANE (Lower Structural-Deck)

Shabogamo Intrusive Suite

9 gabbro, gabbronorite, coronitic gabbro

Trans-Labrador Batholith

8 megacrystic granite, granite, granitoid gneiss

LAC JOSEPH TERRANE (Upper Structural-Deck)

7 quartz syenite

6 quartz monzonite, monzonite, monzodiorite

5 granite, megacrystic granite (locally rapakivi-textured)

4 gabbronorite, gabbro

3 granitoid gneiss

Supracrustal Rocks

2 mafic gneiss

1 paragneiss

The numbers assigned to the rock units do not necessarily imply relative ages. See text for explanation.

lithologic contact

thrust fault (contact between the Churchill Falls and Lac Joseph terranes)

LC-Lac a l'Eau-Claire, AL-Ashuanipi Lake,
TLH-Trans-Labrador Highway

fold-axial-plane surfaces. In the paragneisses, foliations are axial planar to folds of the metamorphic layering and, locally, an earlier foliation indicating that the dominant foliation observed at most outcrops represents at least the second generation of foliation. Deformation is synchronous with high-grade Labradorian metamorphism.

CHURCHILL FALLS TERRANE (CFT)

The CFT is composed of granitic rocks of the ca. 1650 Ma Trans-Labrador batholith and gabbro of the ca. 1430 Ma Shabogamo Intrusive Suite. The Trans-Labrador batholith is composed of equal-grained and megacrystic granite, variably foliated, and granitoid gneiss. Mapping has shown that the Trans-Labrador batholith extends from the part of the CFT that occurs to the east of the map area, around the northern margin of the LJT into the Molson Lake Terrane to the southwest.

The batholith is intruded by Shabogamo gabbro which occurs as fine- to coarse-grained, massive to foliated gabbro that is locally gradational into coronitic gabbro. The coronitic gabbros are defined in the field by the presence of garnet coronas around pyroxene and/or magnetite. Garnet coronas are presumed to be a Grenvillian feature.

Occurrences of gabbro and coronitic gabbro at Lac Joseph have been tentatively correlated with the Shabogamo Intrusive Suite in the CFT (after Connelly, 1988) on the basis of textural and metamorphic similarity. This correlation implies that these rocks are exposed in a structural window through the upper structural-deck (i.e., LJT). A sample of the gabbro from Lac Joseph has been collected for U - Pb zircon geochronology to test this model.

The rocks adjacent to, and on both sides of, the contact between the LJT and the CFT are cut by ductile high-strain zones that strike parallel to the contact between the LJT and the CFT. Hence they are presumed to be related to LJT - CFT tectonic juxtaposition. The contact is not exposed.

Within the LJT in the Ossokmanuan Lake area, the high-strain zone is concentrated within layers of megacrystic granite and paragneiss that are (tectonically?) interlayered with gabbronorite. Ductile high-strain zones, within the CFT, deform the Trans-Labrador batholith and coronitic gabbro. The apparent stability of the coronitic assemblages, the local presence of strained muscovite in retrogressed paragneiss in the LJT, and mylonitic amphibolite-grade versions of gabbroic rocks in the LJT suggest that the strain along the LJT - CFT contact took place at amphibolite-grade.

Previously reported mineralization is restricted to occurrences of disseminated pyrite within gabbroic rocks and, disseminated chalcopyrite and pyrite at the Wynne Showing (UTM coordinates 365450 E, 5865900 N; Newfoundland Department of Mines and Energy, Open File: Lab 326, 1976). This summer's mapping has also revealed several occurrences of disseminated pyrite in the gabbronorite - gabbro unit and the supracrustal rocks in the LJT. Although these showings are only minor, the layered gabbronoritic-gabbroic rocks have potential for PGE mineralization and the supracrustal rocks have some potential for massive sulphide mineralization. Meyer (1989) reports occurrences of muscovite-bearing pegmatites intersected by road construction at kilometre 90 and kilometre 137 on the Trans-Labrador Highway, which are within the area mapped in 1990. High-quality sheet muscovite is used in the electronics industry.

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GEOLOGY, GEOCHEMISTRY AND MINERAL POTENTIAL OF PLUTONIC ROCKS IN THE EASTERN PART OF THE CENTRAL MINERAL BELT OF LABRADOR

Andrew Kerr
Labrador Mapping Section

PROJECT OVERVIEW

This project was initiated in 1985 to assess the mineral potential of (predominantly granitoid) plutonic rocks in east-central Labrador, and to gain an understanding of the anatomy and petrogenesis of rocks that have been traditionally grouped under the heading of "Trans-Labrador batholith". Field work was undertaken during the 1985, 1986 and 1987 field seasons, and the project entered the stage of final report preparation at the end of 1988. Results of the work to date have been highlighted in a number of published articles (Kerr, 1986; 1987; 1988; Kerr and Krogh, 1990).

The final project report, with the same title as this note, was completed and submitted for external review in June 1990. This report emphasizes geological and petrological descriptions of plutonic units and presentation of the geochemical data, and also incorporates a review of possible granite-related mineral occurrences coauthored by Derek Wilton and others at Memorial University of Newfoundland. A number of units and areas are suggested as possible targets for exploration activity directed toward such deposits in future years.

In addition to those objectives of the study directed at evaluation of mineral potential, this project has also involved a number of geochemical, geochronological and isotopic investigations aimed at analyzing petrogenetic and regional geological problems.

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SOME NEW OBSERVATIONS ON THE NAIN AREA

Bruce Ryan
Labrador Mapping Section

The Nain region has long been the target of those attempting to understand the evolution of "anorthosite massifs"; these studies have focussed on the Nain Plutonic Suite (NPS). Most notable among those workers who were and are still active in the area, are E.P. Wheeler II (between 1926 and 1974), and S.A. Morse (between 1971 and 1981) under the Nain Anorthosite Project (NAP). During these studies very little attention was focussed on the gneissic country-rocks surrounding the plutons. A 30-day project studying the gneisses, exposed on part of the island archipelago east of Nain, was carried out in 1990; in addition, the mainland west and north of Nain was also briefly examined. Figure 1 shows the areas examined during the 1990 field season. Some of the preliminary findings of the 1990 field season are:

1) In the region east of Nain, gneisses are all considered to be Archean in age. They are dominated by quartzofeldspathic compositions; predominant among these are layered, migmatized rocks, but also present are younger, diffusely-layered polyphase non-migmatic granitoid rocks. Interlayered with the orthogneisses are paragneiss (including abundant quartzite) and mafic gneisses (largely derived from gabbroic protolith).

2) The gneisses are transected by at least four generations of mafic dykes metamorphosed up to granulite facies. Many of these dykes exhibit deformational features such as folding, boudinage and foliation. This character of the dykes poses problems with

Figure 1. Location map showing areas examined during the 1990 field season.

interpretation of age and tectonic significance: - Are they lower Proterozoic dykes deformed and metamorphosed by the Hudsonian Orogeny (thus indicating that the Proterozoic orogenic front is much farther east than previously known)? Are they lower Proterozoic dykes, deformed and metamorphosed by emplacement of nearby anorthositic plutons (thus indicating "regional contact" metamorphism and deformation accompanying magmatism)? Are the dykes middle Proterozoic precursors to the anorthositic plutons, tectonized by subsequent larger pulses of magmatism? Are dyke features a combination of all the above processes?

3) Metamorphic grade within the area varies from granulite facies to amphibolite facies, the latter seeming to be a retrogressive transformation of the former. The age of the high-grade metamorphism is unclear. It is obvious that some of the dykes of (3) cross-cut earlier granulite-facies migmatites, but themselves exhibit granulite-facies assemblages. The demarcation of Archean regional metamorphism, possible lower Proterozoic regional metamorphism, and mid-Proterozoic contact metamorphism from the plutons has yet to be addressed.

4) Several areas, previously considered to comprise Archean gneisses, appear instead, to be deformed intrusions related to the Nain Plutonic Suite. These are recrystallized and foliated, predominantly noritic rocks, locally containing inclusions of recrystallized leuconorite - anorthosite and cut by deformed and metamorphosed basic dykes. The largest of these bodies occurs on Satok Island and nearby islets.

5) It is now recognized that strongly foliated and recrystallized noritic and anorthositic rocks are a widespread constituent of the plutonic complex north and west of Nain. Foliated to gneissic norite occurs, for instance, west of Webb Bay, east of Conch Bay, west of Nain town, north of Anaktalik Brook and in the area of Kingurutik Lake. The foliated noritic rocks have been described previously as "stretched anorthosite" in several NAP reports, and as "granulite of uncertain origin" by E.P. Wheeler (unpublished manuscript). Recrystallized anorthosite seems to have gone largely unnoticed by many previous workers, but appears to be the dominant component of the white-weathering terrain in the Nain area, corresponding to Wheeler's "pale facies" anorthosite. Deformation preceded recrystallization in these rocks, too, but cannot be recognized easily because of their largely monomineralic character. Mt. Lister, the area west of Webb Bay and the area south of Nain Bay are all underlain by variably recrystallized anorthosite.

Such deformed and recrystallized plutonic rocks as those noted here and in (4) appear to be foreign to an anorogenic (i.e., non-stressed) environment as envisaged for the emplacement of the Nain Plutonic Suite. Three options are possible viz. (i) these plutons are not related to the Nain Plutonic Suite and attest plutonism of NPS-type, prior to an episode of widespread deformation and metamorphism, perhaps as old as, or older than, the ca. 1800 Ma Hudsonian Orogeny, (ii) these plutons are early members of the Nain Plutonic Suite that were deformed and recrystallized during emplacement, perhaps at greater depth than younger non-deformed members of the suite or (iii) these plutons are early members of the Nain Plutonic Suite that were deformed and metamorphosed by events accompanying or slightly preceding emplacement of the younger members.

The recognition of a multiple dyke chronology, widespread post-dyke metamorphism and deformation in the gneiss complex, and widespread recrystallization and deformation of the anorthositic rocks make the geological history of the Nain area more complex than previously believed. Geochronological studies are being undertaken in an attempt to unravel some of the relationships documented this year, but a re-examination of the whole Nain area is warranted in order to fully document the extent of the various rock types and relationships encountered this year.

NAIN - NUTAK AREA: A NEW 1:500,000-SCALE COLOUR COMPILATION

Bruce Ryan
Labrador Mapping Section

The Nain - Nutak area had been the geological focus of the late E.P. Wheeler II from 1926 until his death in 1974; an incredible record of 48 years of research. Dr. Wheeler's legacy to later workers in the area includes a series of 1:63,360-scale maps, copies of which are filed at the Department of Geology and Geography, University of Massachusetts, Amherst, Massachusetts, and at the Geological Survey Branch, Department of Mines and Energy, St. John's. These maps were compiled at 1:200,000 scale by A. Harris at the Department of Mines and Energy in 1980, and released as a two-colour series in 1984.

Between 1971 and 1981, detailed studies in the Nain area (under the umbrella of the Nain Anorthosite Project led by Dr. S.A. Morse of the University of Massachusetts) built further upon the foundation laid by E.P. Wheeler. As a consequence, both an informal and formal stratigraphic nomenclature began to appear in the geological literature, especially with regard to the plutonic rocks of the Nain area. Between 1985 and 1989, regional 1:100,000-scale transects from the coast to the Labrador - Quebec border were carried out in the Voisey Bay area by the Newfoundland Department of Mines and Energy (B. Ryan) and in the Nutak area by the Geological Survey of Canada (GSC) (I. Ermanovics). These surveys expanded upon the 1:250,000-scale reconnaissance mapping of F.C. Taylor (GSC) conducted in the early 1970's, and led to regional subdivisions of the Archean and Proterozoic gneisses, and the definition of several structurally and stratigraphically distinct zones within these regions.

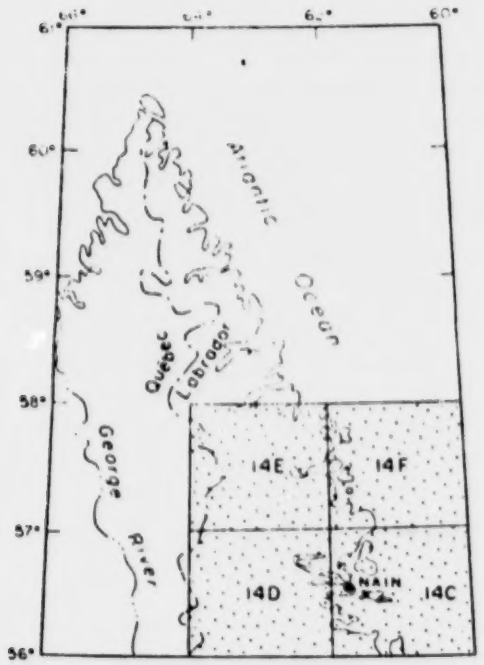

Figure 1. Stippled area shows region covered by the Nain - Nutak map sheet.

The Newfoundland Department of Mines and Energy has now released a preliminary 1:500,000-scale colour map (Figure 1), which incorporates all work carried out in the Nain - Nutak area up to 1989. The map serves several purposes:

1. It is a testimony and dedication to the pioneering efforts of the late E.P. Wheeler II, whose leg-work provided the basis for all subsequent surveys.

2. It brings together the results of years of work by a group of geologists who have focussed on individual aspects of the area.

3. It shows for the first time the major subdivisions of the gneissic and plutonic terranes, and incorporates the stratigraphic nomenclature commonly employed in references to the area.

4. It is the first published map to show the regionally-recognizable four-component igneous assemblage that constitutes the

Nain Plutonic Suite, a world-famous example of an anorogenic magmatic terrane.

5. It is meant to provide a basis and focus for continuing work in the region because much of the information portrayed on the map has been previously available only to a small and widely-dispersed group of individuals actively involved with ongoing work in the area, and

6. It represents the first in a planned series of 1:500,000-scale map sheets to be published prior to the production of the next geological map of Labrador.

GEOLOGICAL RECONNAISSANCE SURVEY OF NORTHERNMOST LABRADOR

D. Wilton[1] and R. Wardle
Labrador Mapping Section

Approximately two weeks were spent on a reconnaissance investigation of the Labrador coast between McLelan Strait and Eclipse Channel. Work was divided into two components: i) transects across major tectonic features of the Nain - Churchill boundary zone (R. Wardle), and ii) an examination of the economic potential of Archean anorthosites in the area (D. Wilton). Figure 1 illustrates the study area.

ECONOMIC POTENTIAL OF ARCHEAN ANORTHOSITES[2]

The Nain - Churchill boundary zone in the northern tip of the Labrador Peninsula is the locus for a number of podiform to sill-like anorthosites. It has been previously suggested that a linear anorthosite body in the Nachvak Fiord area predated the early Proterozoic dyke swarm and thus is Archean in age. This has given rise to comparisons with the mid-Archean Fiskenaesset Complex of western Greenland, which is a layered anorthosite intrusion that was dismembered by 2900 to 2800 Ma old magmatism (Myers, 1985). According to Ghisler (1976), anorthosite and leucogabbro account for ~87 percent of the complex with the remainder being gabbro (10 percent) and ultramafic rocks (3 percent). Windley (1984) suggested the Fiskenaesset Complex is a chromium metallogenic province because of the presence of chromite seams.

The objective of this part of the study was to examine the anorthosites in the Ekortiarsuk Fiord - Hutton Peninsula area to (i) confirm the postulated Archean age, (ii) define their economic (Cr, PGE, Ni) potential, (iii) determine their geochemical compositions and thus define their petrogenesis, and (iv) evaluate their significance to the evolution of the KSZ.

Anorthosite bodies chosen for examination were on the (a) Hutton Peninsula, (b) southern end of Ekortiarsuk Fiord (known as Noodleook Fiord, but not shown on figure), (c) west side of Eclipse Harbour, (d) east side of Eclipse Harbour (Bibb Cove), and (e) east side of Eclipse Channel based on Taylor's (1979) mapping. At site (a) the main rock type is grey gneissic anorthosite, which contains layers and bands of massive amphibolite (typically with garnet) and/or pyroxene-bearing gneiss. The anorthosite is cut in places by Early Proterozoic (?) dykes which, define the anorthosite as Archean. Seams of magnetite, up to 0.5 to 0.75 cm thick, and rusty zones containing pyrite and chalcopyrite, up to 8 cm thick, occur in the anorthosite gneiss and amphibolite bands. Though magnetite is the only spinel definitively identified, the weak magnetism of some seams suggests the possible presence of chromite.

The areal extent of the anorthosite at site (b) is smaller than that outlined by Taylor (1979) and the supracrustal gneiss unit was found to be complexly interleaved with the anorthosite. Aside from the gneissic anorthosite and amphibolite layers, rock types at this site include gabbro layers and ultramafic (metapyroxenite?) and massive recrystallized pyroxene pods (individual crystals up to 0.3 m long). Magnetite (± other spinels) are present in seams. This body is the

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[2] Field work by D. Wilton

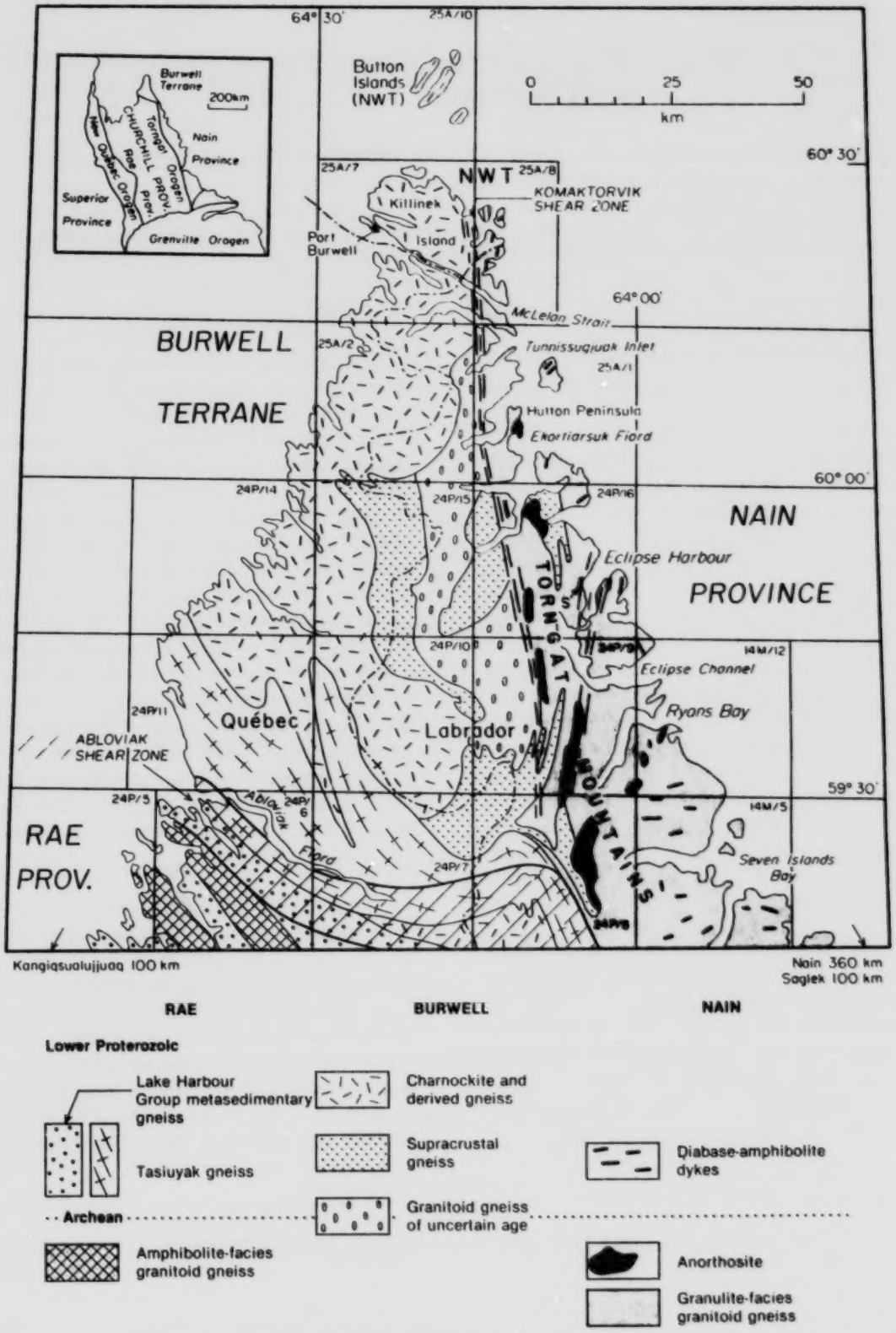

Figure 1. General geological map of northern Labrador and Quebec.

subject of a BSc. (Hons.) dissertation study by Mr. D. Phillips of the Department of Earth Sciences, Memorial University of Newfoundland.

At site (c) there are large megaboudins (up to 15 m long) of gneissic anorthosite within more amphibole-rich layers. There are also ultramafic, gabbroic and metasedimentary layers interleaved with the anorthosite. Sparse pyrrhotite was also found in some of the ultramafic rocks. Associated with this anorthosite zone are very rusty layers (up to 6 to 8 m wide) of gabbro and anorthosite containing significant concentrations of sulphide. The sulphides are mainly pyrite and pyrrhotite with minor chalcopyrite. These sulphide-bearing zones extend for a distance of over 5 km. Assay contents in these sulphide occurrences, from what is tentatively called the Sugar Shack Occurrence, have not been determined as yet.

The anorthosite body mapped by Taylor (1979) at site (d) could not be confirmed, however, a large band of coarse-grained hornblende gabbro was found within quartzo-feldspathic gneiss. At site (e) the anorthosite was not found, but there are several pods and lenses (up to 8x30 m) of granulite-facies metapyroxenitic rock. These also contain minor pyrite.

TECTONIC FEATURES OF THE NAIN - CHURCHILL BOUNDARY ZONE[1]

The principal tectonic divisions of the region are the Nain and Churchill provinces. The Churchill Province is subdivided into the Burwell terrane and the Rae Province. The Nain Province consists of Archean granulite-facies gneiss, including a chain of meta-anorthosite bodies, all intruded by a suite of Early Proterozoic dykes. The Burwell terrane comprises an undated assemblage of granitoid and supracrustal gneiss, and extensive amounts of charnockite. The Rae Province in this area is composed of the metasedimentary rocks of the Tasiuyak gneiss and Lake Harbour Group, in addition to belts of charnockite and reworked granitoid gneiss (Archean basement). The Burwell terrane is separated from the Rae Province by the Abloviak shear zone, and from the Nain Province by the postulated Komaktorvik shear zone (KSZ), the position of which has been previously inferred from aeromagnetic data and Landsat imagery.

Objectives of the survey were to confirm the existence of: i) Nain-type Archean crust in this part of Labrador, and ii) the Komaktorvik shear zone. Work was concentrated along the east-west transects offered by Ekortiarsuk Fiord and Tunnissugjuaq Inlet, supplemented by visits to Eclipse Harbour and Eclipse Channel. The eastern part of these transects consists of granulite-grade granitoid gneiss containing lenticular units of meta-anorthosite and related metagabbroic and ultramafic rocks. The fact that these rocks are cut by Early Proterozoic dykes apparently confirms their suspected Archean age and Nain Province affinity.

The Archean rocks, together with the dykes, have been zonally reworked and retrograded to amphibolite facies within shear zones which increase in intensity and abundance to the west. Shearing culminates in the KSZ, which is best developed over a 2.76 km width in Tunnissugjuaq Inlet, where it juxtaposes straightened and mylonitized Archean gneiss on its eastern side against mylonitized megacrystic granite and charnockite on the west. Charnockite to the west of the KSZ is only moderately foliated (and is therefore probably of Early Proterozoic age) and may be continuous with similar rocks exposed on the Ungava Bay side of the Burwell terrane. The KSZ is characterized by down-dip lineation and is inferred to have developed through west-side-up movement.

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[1] Field work by R. Wardle

At Ekortiarsuk Fiord, the KSZ is less prominent and is bordered to the west by a Burwell terrane unit of uncertain age that comprises banded granitoid gneiss and intercalations of rusty supracrustal gneiss thought to be of Archean age.

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REGIONAL GEOLOGY - NEWFOUNDLAND

PALEONTOLOGICAL INVESTIGATIONS IN NEWFOUNDLAND

W.D. Boyce, J.S. Ash, I. Knight, B.H. O'Brien, J.P. Hayes and L.W.J. Mandville
Newfoundland Mapping Section

WESTERN NEWFOUNDLAND

Hughes Brook - Goose Arm

Although the geology of the Hughes Brook - Goose Arm area was first outlined by Lilly (1961, 1963), paleontological information from the autochthonous Cambrian - Ordovician rocks has been notably lacking. Levesque (1977, page 79) reported unidentified early Middle Cambrian ptychopariid trilobite and inarticulate brachiopod fragments from the base of the Wolf Brook Formation on the north and south shores of Goose Arm. Later, Boyce *in* Gillespie (1983, page 22; Plate 1) illustrated the late Middle Cambrian trilobite *Kootenia cloudensis* Howell, 1943, collected (by Gillespie) from an inland exposure of the Penguin Cove Formation between Goose Arm and Old Mans Pond.

At the request of Westfield Minerals Limited, Knight and Boyce rendered stratigraphic assistance in Goose Arm (see Wilkinson, 1983). As a result, seven previously unreported fossiliferous localities were sampled (Glover *in* Wilkinson, 1983, Appendix A, page 13, Figure 8); Boyce discovered faunas indicative of the early Late Cambrian Dresbachian Stage (*Cedaria* - *Crepicephalus* zones) and the latest Cambrian Trempealeauan Stage (*Saukia* Zone). In 1990, more assiduous biostratigraphic sampling resulted in the discovery of many additional macrofossil localities (Figure 1). Fifty-seven horizons yielded macrofossils, principally trilobites and inarticulate brachiopods. Twenty-two collections were obtained from the north shore of Goose Arm, thirty-five from the south shore. The units investigated were the Penguin Cove, Petit Jardin and Berry Head formations.

The Penguin Cove Formation yielded Middle Cambrian faunas correlative with those

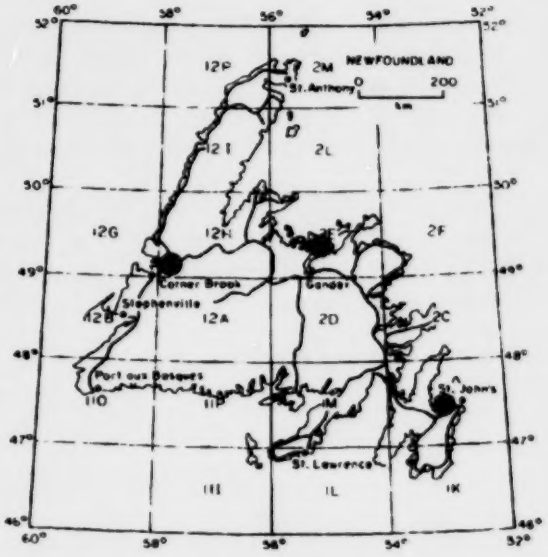

Figure 1. Index map of sample localities.

of the Hawke Bay Formation (Bridge Cove Member) and the March Point Formation of the Canada Bay area (Knight and Boyce, 1987). Trilobite and inarticulate brachiopod faunas correlative with the early Late Cambrian *Cedaria* and *Crepicephalus* zones were recovered from a stromatolitic limestone interval within the Petit Jardin Formation.

The most significant result of the investigations in Goose Arm may be the discovery of a fossiliferous Cambrian - Ordovician boundary interval in the Berry Head Formation. Trilobite faunas indicative of the *Saukia*, *Mississquoia* and *Symphysurina* zones were discovered in limestone beds on the north shore of Goose Arm. Elsewhere in western Newfoundland this interval generally comprises unfossiliferous dolostone.

The Reluctant Head Formation

The Reluctant Head Formation is an enigmatic unit comprising thinly interbedded ribbon limestone and dolostone as well as limestone breccia/conglomerate. It may be as thick as 250 m but is of limited areal extent (Gillespie, 1983). In 1990, fourteen macrofossil collections were obtained from the upper part of the Reluctant Head Formation exposed on the Hughes Brook - Goose Arm logging road system south of Old Mans Pond. Well-preserved trilobites and inarticulate brachiopods suggest a late Middle Cambrian (*Bolaspidella* Zone) to early Late Cambrian (*Cedaria* to *Crepicephalus* Zone) age for the unit. The Reluctant Head Formation is therefore partly equivalent to the Petit Jardin Formation.

CENTRAL NEWFOUNDLAND

Bay of Exploits

During the course of the investigations, a previously unrecorded shelly fauna was recovered from limestone lenses and layers in turbidite deposits exposed on Upper Black Island. The fauna is dominated by trilobites, although one articulate brachiopod was collected. Trinucleid and cyclopygid trilobites indicate a Late Ordovician, probably Ashgill age.

EASTERN NEWFOUNDLAND

Topsail Beach

North of Topsail Beach, green, grey and black shales and siltstones of the Adeyton and Harcourt groups are juxtaposed against mafic volcanic rocks of the Harbour Main Group along the Topsail Fault. Most regional geology maps have included the Cambrian strata with the Harbour Main Group and placed the fault along the beach (i.e., Rose, 1952). In reality, the trace of the fault is marked by a break in slope inland, and the Cambrian strata are well exposed along the beach parallel to the fault (Dawson, 1963; Hayes and O'Driscoll, 1989).

Middle Cambrian trilobites and inarticulate brachiopods were obtained from two horizons within the Chamberlains Brook Formation (Adeyton Group). Near the Topsail Beach parking area, blue-grey and blue-green shale and siltstone yielded *Eccaparadoxides lamellatus* (Hartt *in* Dawson, 1868). Farther north, a distinctive massive, brown weathering, dark blue-grey trilobite coquina bed was found; it is probably analogous to the "rottenstone" marker bed of the Kelligrews' Quarries (Boyce, 1988, page 49). This horizon yielded the following:

Brachiopoda-Inarticulata
- Gen. et sp. undet.

Trilobita
- *Bailiaspis elegans* (Hartt *in* Dawson, 1868)
- *Ctenocephalus terranovicus* Resser, 1937
- *Eccaparadoxides lamellatus* (Hartt *in* Dawson, 1868)

The above fossils are indicative of an early Middle Cambrian *Eccaparadoxides bennetti* Zone age (see Boyce, 1988, Figure 5).

Dark grey to black shale and slate of the Manuels River Formation (Harcourt Group) yielded unidentifiable trilobite and inarticulate brachiopod remains.

PALEONTOLOGY DATABASE

Fossils are important for stratigraphic correlation and relative age dating, consequently, Boyce, Ash and Mandville have begun compiling a paleontological database for the province. This database will incorporate all available information from academic, government and industry sources (published and unpublished). Relevant data such as location, rock formation, collector, fossils identified, geological system,

faunal province, etc. will be included, and the database will direct users to the original reference for further information.

For maximum accessability, the database will be released in ring binder form as well as on MS-DOS-, Macintosh- and Atari-format floppy disks.

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THE GEOLOGY OF THE ISLAND OF NEWFOUNDLAND: MAP 90-01

Stephen Colman-Sadd, John Hayes and Ian Knight
Newfoundland Mapping Section

A new colour map, showing the bedrock geology of the island of Newfoundland, was released by the Geological Survey Branch in April 1990 (Map 90-01). The map is at a scale of 1:1,000,000 and supersedes the preliminary map at a similar scale that was released in 1983 by Jim Hibbard.

The new map was compiled directly from original sources, most of which are publications of the Geological Survey Branch and the Geological Survey of Canada; a number of contributors generously provided unpublished material. The 1983, compilation of insular Newfoundland geology proved invaluable as a starting point and for developing a general philosophy for grouping units.

The number of geologic units is the maximum considered appropriate to the scale. In general, faults are only shown if they form a contact between units, but are extended within units where this is necessary to give a reasonable depiction of relationships; a few particularly significant structures are shown regardless of whether they occur at a contact.

The colours distinguish between the principal rock types (e.g. red for granitoid intrusions), and shades indicate age differences. This scheme is preferred to one based primarily on age, because insular Newfoundland has a great variety of rock types within a relatively restricted age range, and in most places rock type is known more precisely than age.

The map legend consists of two parts which are inset one into the other, but which can be used independently. The coloured part of the legend provides a very brief description of each unit and represents it schematically in time and space; the amount of information is sufficient for most purposes. The uncoloured text blocks have a conventional format and provide more detailed lithologic descriptions, as well as examples of stratigraphic names.

All producing mineral deposits that occur in bedrock are shown. Past-producers and prospects are selected on the basis of the perceived likelihood of future production, historic importance, or representation of a deposit type. Inclusion of mineral deposits on the legend as well as on the map allows easy recognition of economically important units.

The map is also available in digital format for computer manipulation.

PROVENANCE INVESTIGATIONS IN THE AVALON, GANDER AND DUNNAGE ZONES

Tomasz Dec
Newfoundland Mapping

In February 1990, two additional samples of tuffaceous sandstone and conglomerate from the upper part of the Connecting Point Group were examined by micro-probe, to determine the chemistry of detrital clino-pyroxenes. The major-element composition of relict calcic augites and endiopsides confirms the island-arc provenance of the volcaniclastic rocks, reported earlier in Dec *et al.* (1989) and Dec (1990). The results plot in the clinopyroxene field found in recent "orogenic basalt". The clinopyroxene chemistry implies a calc-alkaline rather than a tholeiitic affinity for the parent magmas. The clinopyroxenes which were examined, have not undergone any significant reworking and recycling. Hence, their chemistry provides a unique insight into the Late Precambrian magmatism of the Avalon Zone, which is synchronous with the sedimentation of the Connecting Point Group. Results of the geochemical and petrographic investigations in the Eastport basin have been presented at the International Sedimentological Congress, Nottingham (Dec *et al.*, 1990) and will be submitted as a paper (Dec *et al.*, in preparation).

An initial set of one-hundred major-element, micro-probe analyses and SEM images of detrital chromites from the Davidsville Group and from Limestone Conglomerate (Mount Cormack Subzone) have also been acquired in February 1990 with the objective to constrain provenance of the ophiolitic detritus, wide-spread in the Ordovician sediments of Newfoundland (Dec and Colman-Sadd, 1990).

Petrographic investigations of sandstones and conglomerates, from the Silurian La Poile Group (Bishops Pond area), have been carried out this past summer and will be maintained in the future.

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GEOLOGY OF THE RAMEA ISLANDS - PRELIMINARY REPORT

W. Lawson Dickson and John P. Hayes
Newfoundland Mapping Section

The Ramea Islands are situated about 6 km off the south coast of Newfoundland and approximately 20 km southeast of Burgeo. The islands are underlain by mafic to felsic intrusive rocks that have been correlated with the Burgeo Intrusive Suite on the adjacent mainland (Riley, 1959; O'Brien *et al.*, 1986; Dickson *et al.*, 1989). However, the results of a brief summer field survey indicate that this correlation may be tenuous.

LITHOLOGIES

The oldest recognized unit is represented by several 1000 m^2 metagabbroic inclusions (Unit 1) within granitic units 2, 3 and 6 (Figure 1). The metagabbro is generally weakly foliated to massive but within Unit 2, it is strongly deformed.

Unit 2 is an intensely deformed, coarse grained, feldspar porphyritic, hornblende - biotite granite. The phenocrysts are generally less than 2 cm long. The most deformed parts of this unit (subunit 2a) form black, fine grained, parallel mylonite zones within the strongly foliated granite. Subunit 2b is interpreted as a K-feldspar porphyroclastic, hornblende - biotite granite that has been recrystallized.

Unit 3 is composed of medium grained, equigranular and K-feldspar porphyritic biotite granite. The unit extends from Ramea Colombier Island northeastwards to the eastern end of Great Island. Unit 3 has intruded the foliated granites of Unit 2. Xenoliths of mylonitic Unit 2 also occur within Unit 3. Subunit 3a is cut by numerous anastomosing, brittle shears along the northwestern side of Northwest Island and Great Island. **Unit 4** is a massive, biotite - hornblende granodiorite that has intruded and contains xenoliths of Unit 3.

Unit 5 is a distinctive massive, leucocratic biotite granite. The contact of Unit 5 with Unit 2 at Ramea Harbour, is intrusive and dykes of weakly cleaved, leucocratic granite (subunit 5a) cut intensely deformed granite of Unit 2. Northwest Head is also underlain by massive, leucocratic granite (S.J. O'Brien, personal communication, 1990) which has intruded Unit 2. **Unit 6** consists of isolated felsic dykes of uncertain affinity that have intruded units 2, 3, 4 and 5. Numerous felsic dykes within Unit 2 at Muddy Harbour may be offshoots from Unit 3.

Unit 7 is medium grained, massive, biotite - hornblende quartz diorite. It has intruded Unit 2 and probably cuts Unit 5. A felsic dyke within Unit 7 may, however, be related to Unit 5. **Unit 8** comprises all diabase dykes in the Ramea area and a small diabase stock around the southern entrance to Ramea Harbour. The dykes are locally plagioclase porphyritic and are locally over 10 m thick. Along the southeastern margin of Unit 2 in Ramea Harbour, diabase dykes appear to have remobilized the foliated granite with the formation of an elongate zone of intrusion breccia composed of diabase fragments in a matrix of medium grained xenolith-rich granite.

DEFORMATION

The dominant structure in the Ramea area is a major northeast-trending, steeply dipping, ductile shear zone that occurs entirely within Unit 2. Mylonitization is most intense along a zone that spans the main channel southeast of Northwest Island. The zone continues eastward along the south coast of Great Island and the adjacent islands. Along the main channel, 1 m-wide parallel, 060°-trending, steeply dipping zones of black, flinty mylonite occur within the granite. Away from the channel, the granite is

porphyroclastic and contains narrow (1 cm), anastomosing bands of black, fine grained mylonite. Kinematic indictors generally indicate dextral movement. Mineral lineations are rare and plunge gently to the southwest; definitive C-S fabrics were not found.

The mylonitization predates the intrusion of units 3, 5, 6, 7 and 8 as these units crosscut the tectonic fabrics and are brittly deformed or massive. A few granite veins crosscut the mylonitic fabric and contain a weak cleavage that is parallel to the mylonitic fabric and axial planar to open folds of the granite veins. The mylonitic fabric is locally overprinted by an east-trending fracture cleavage. This cleavage parallels fractures and shears in the post-mylonitization units 3a and 5.

Subunit 3a is deformed along a 500 m to 1 km-wide belt of brittle fracturing and shearing along the northwest side of Northwest Island and Great Island. Brecciation is most intense along the north-facing coast. Several massive diabase dykes have intruded along faults and near contacts between the main units.

In summary, early possibly dextral, ductile deformation is restricted to Unit 2. Widespread brittle deformation within Unit 3 is strongest along the north-facing sides of the Ramea Islands. Brittle faulting and subsequent diabase dyke intrusion are the latest events exhibited in the Ramea Islands.

REGIONAL CORRELATIONS

The mylonitic Unit 2 is similar to mylonitic granite near Rencontre West that has been correlated with the Silurian Gaultois Granite (Dunning *et al.*, in press). Unit 5 is similar to parts of the Devonian François Granite. Diabase dykes are common along the south coast (see O'Brien *et al.*, 1986 and Dickson *et al.*, 1989 for a summary of the geology of the Burgeo area). The other units appear to be unique to Ramea.

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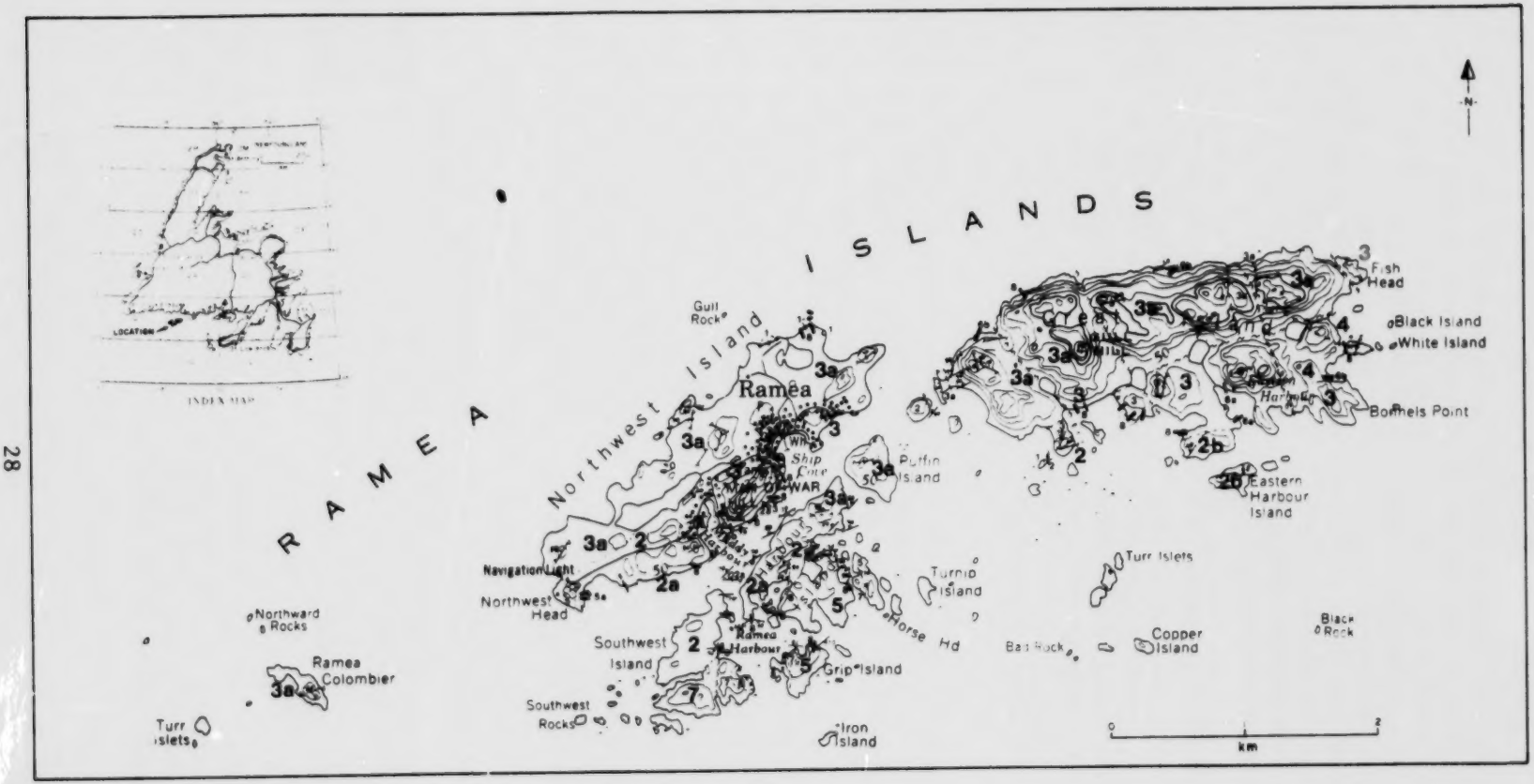


Figure 1. Geology of the Ramea Islands

LEGEND

?DEVONIAN OR YOUNGER

8 Massive, medium-grained diabase plug and dykes

7 Massive, medium grained, biotite - hornblende gabbro and quartz diorite

6 Felsic dykes of unknown affiliation; **6a**, weakly cleaved, pink, fine-grained felsite dykes; **6b**, massive, pink, fine-grained biotite granite dykes

5 Massive to weakly cleaved, pink, equigranular, leucocratic, biotite granite; **5a**, fine-grained granite dykes

?SILURIAN - DEVONIAN OR OLDER

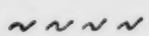
4 Grey, massive to sheared, medium grained, equigranular biotite - hornblende granodiorite

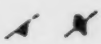
3 Massive, medium-coarse grained, K-feldspar porphyritic, biotite granite; **3a**, pink, fractured and sheared, medium to medium-coarse grained, equigranular to K-feldspar porphyritic, biotite granite

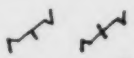
2 Black and pink, medium to coarse-grained, K-feldspar porphyroclastic, strongly foliated to mylonitic biotite granite; **2a**, black, fine to very fine grained, feldspar porphyroclastic, mylonitic granite; **2b**, black and pink, foliated, medium grained, metamorphosed, K-feldspar porphyroclastic, biotite granite

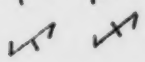
1 Medium to coarse grained, massive to foliated metagabbro and diabase

SYMBOLS

Fault (approximate)..... 

Mylonitic foliation (inclined, vertical)..... 

Brittle shear fabric (inclined, vertical)..... 

Cleavage (inclined, vertical)..... 

Mineral layering (inclined).....

Mineral lineation (with inclination).....

Crenulation lineation (with inclination).....

Dykes (mafic, felsic, granitic).....

NEW ANALYTICAL RESULTS FROM THE AVALON HIGH-ALUMINA BELT AND MAFIC VOLCANIC ROCKS OF THE HARBOUR MAIN GROUP

John P. Hayes[1] and Cyril F. O'Driscoll[2]
[1]Newfoundland Mapping Section; [2]Mineral Deposits Section

In 1989, the geology of the alteration system hosting the Oval Pit pyrophyllite Mine was investigated (Hayes and O'Driscoll, 1989, 1990). A regional-scale alteration system, named the eastern Avalon high-alumina belt, was defined on the basis of the study. Several areas containing anomalous concentrations of gold in bedrock were outlined. This report releases further gold data and describes a base-metal showing within the mafic volcanic rocks.

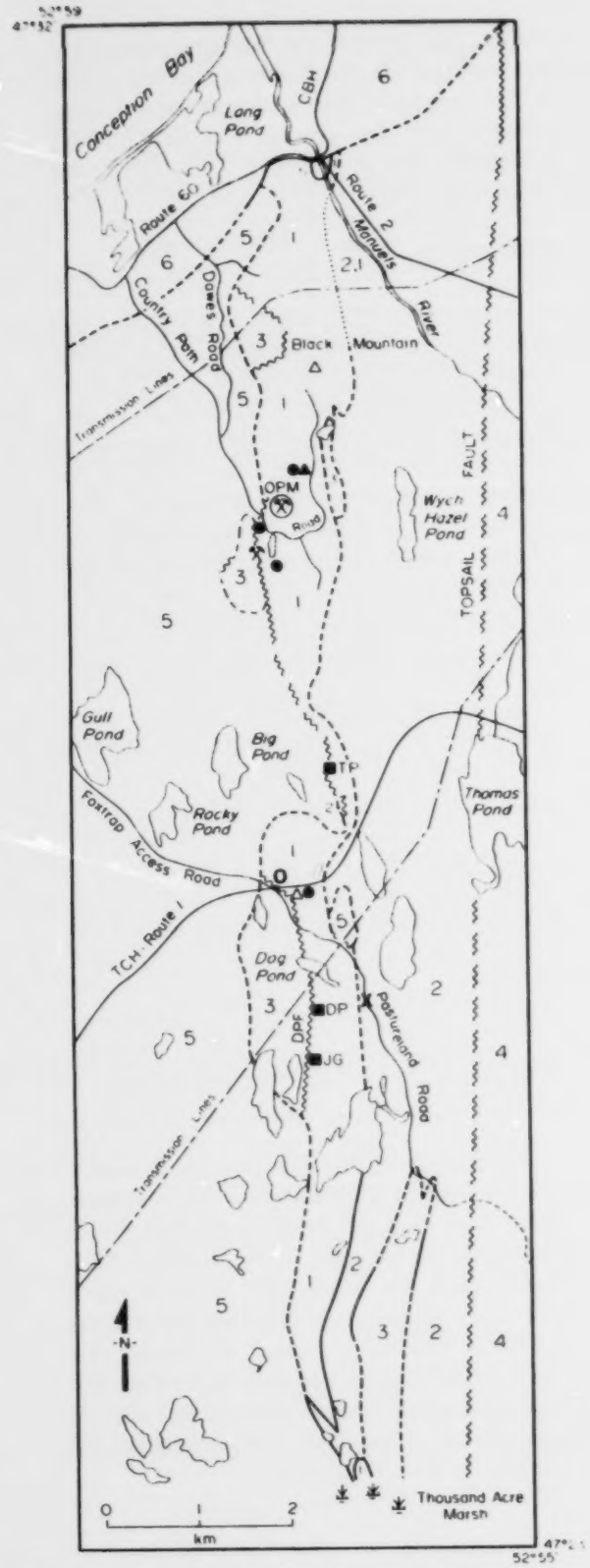
SUMMARY OF THE GEOLOGY OF THE EASTERN AVALON HIGH-ALUMINA BELT

The alteration system is hosted in Late Precambrian rhyolitic volcanic rocks of the Harbour Main Group (Unit 1). The felsic rocks form a sequence of welded and recrystallized crystal and lithic tuffs and associated with minor conglomerate. Abundant lithophysal zones, ash-flow layering, interbedded lithic and crystal tuffs and locally fluvial conglomerates indicate that the rhyolitic rocks represent a period of subaerial volcanism. The alteration associated with the eastern Avalon high-alumina belt is developed within a north-trending shear system, which cuts the ash-flow tuff sequence.

Three main alteration types are developed along the belt, namely, silicification, sericitization and pyrophyllitization (see Hayes and O'Driscoll, 1989). The style of alteration is variable. Brecciation and mm-scale quartz veining in the silicified zones indicate that silica was introduced during periods of hydrothermal brecciation. Sericite and pyrophyllite are hosted by discrete structures in the host rock. Early sericitic alteration is hosted by conjugate brittle shears at a high angle to the overall trend of the belt. With increased sericitization and the development of pyrophyllitization the rock mass becomes increasingly schistose. Structures at this stage are oriented parallel to the trend of the belt and presumably the boundaries of the shear zone.

The most intensely altered and sheared areas in the belt are marked by pyrophyllite occurrences at the Oval Pit Mine, Mine Hill, Trout Pond, Dog Pond and Jakes Gully (Figure 1). The occurrences mark extreme degrees of leaching of the rhyolitic rocks. Pyrophyllite is hosted by discrete shears within these areas and crudely enveloped by the more regionally developed sericitic alteration. Silicified volcanic rocks occur along the margins of the high-alumina and sericitic alteration.

The structures and alteration within the high-alumina zone do not appear to continue into overlying units. Outcrops of basalt and a debris flow (Unit 2) exposed on Mine Hill are relatively undeformed in comparison to the adjacent high-alumina alteration. The debris flow contains silicified and unsilicified blocks of ash-flow tuff, indicating the source area was already partly altered. Sedimentary rocks overlying the alteration zone at the Oval Pit Mine (Unit 3) contain clasts of pyrophyllized and sericitized felsic volcanic rocks derived from the alteration system. The absence of the shear fabrics in the overlying rocks indicate that the contact is an angular unconformity. Unit 3 rock types are similar to the Conception Group and are possibly outliers of this unit. Locally, rocks similar to the Conception Group (Unit 3) are interbedded with the mafic volcanic rocks suggesting a conformable relationship between the units (Dawson, 1963; Hayes and O'Driscoll, 1990).



LEGEND

CAMBRIAN

ADEYTON AND HARCOURT GROUPS

6 *Shale, siltstone and sandstone with conglomerate at base*

PRECAMBRIAN

HOLYROOD INTRUSIVE SUITE

5 *Granodiorite, granite and minor feldspar porphyry and gabbro*

CONCEPTION GROUP

4 *Siltstone and sandstone (may be equivalent to Unit 3)*

HARBOUR MAIN GROUP

3 *Siltstone, sandstone and minor conglomerate*

2 *Basalt flows, ash and lapilli tuff, minor interbedded debris flows and greywackes*

1 *Rhyolite ash-flow tuff, lithic and crystal tuffs; minor epiclastic rocks*

SYMBOLS

Fault (defined, approximate)

Geological boundary (defined, approximate, assumed)

Main Pyrophyllite Occurrences

– Oval Pit Mine, active

– Mine Hill Quarry, dormant

– Prospects:

TP – Trout Pond Prospect

DP – Dog Pond Prospect

JG – Jakes Gully Prospect

Anomalous Gold Values and Occurrences

▲ *– 1060 ppb*

○ *– 580 ppb*

△ *– 210 – 327 ppb*

• *– 50 – 80 ppb*

Zn, Cu, Pb showing X

Abbreviations

DPF – Dog Pond Fault

CBH – Conception Bay Highway

TCH – Trans-Canada Highway

Figure 1. *Geology and mineral occurrences of the eastern Avalon high-alumina belt (after Hayes and O'Driscoll, 1989).*

The Holyrood Intrusive Suite contains roof pendants and xenoliths of rhyolitic ash-flow tuff (Unit 1). Some xenoliths are silicified and indicate that the intrusion of the Holyrood Intrusive Suite postdates the alteration system. Equally convincing evidence of intrusion of the Holyrood Intrusive Suite into mafic volcanic rocks of the Harbour Main Group or the Conception Group in the field area is absent.

A preliminary interpretation of the field mapping and data collected indicates the following sequence of events in the geological evolution of the area:

1. A period of subaerial ash-flow tuff volcanism.

2. Development of high-alumina alteration system (s) possibly in association with early stages of emplacement of the Holyrood Intrusive Suite.

3. Final intrusion of the Holyrood Intrusive Suite followed by extensional mafic volcanism and development of "Conception Basin".

4. Deposition of the Conception Group, in part concomitant with mafic volcanism, unconformably upon the altered felsic volcanic and granitic substrate.

METALLOGENY AND NEW OCCURRENCES

Precious Metals

Published anomalous gold values have been shown to be associated with silicified pyritized felsic volcanic rocks marginal to the high-alumina alteration (Hayes and O'Driscoll, 1990). New analytical results from samples collected in 1989 indicate further anomalous gold concentrations in bedrock in the central part of the belt. A composite grab sample of pyritized, silicified and partly sericitized ash flow tuff from the top of the outcrop of felsic volcanic rocks at the junction between the Foxtrap Access Road and the Trans-Canada Highway returned a value of 580 ppb gold and 8.10 ppm silver. Other samples from this general area also returned anomalous gold (327 and 79 ppb, Hayes and O'Driscoll, 1989).

Base Metals

A minor base metal occurrence was discovered in mafic volcanic rocks of the Harbour Main Group exposed in a gravel pit on the Pasture Land Road. The mineralization appears as fine grained pyrite in a widely spaced network of narrow (< .5 cm) fractures and veinlets. In part of the exposure intense micro-veining and sulphide mineralization is accompanied by silicification forming a small pod (10 x 50 cm pod) of mineralized breccia. Analyses from this lense are given in Table 1.

Table 1: Cu, Pb and Zn analyses from mineralized mafic volcanic rocks, Pastureland Road, Foxtrap.

	Cu	Pb	Zn
Breccia	1080 ppm	1030 ppm	2820 ppm
Boundary of pod	1470	1060	5120
Silicified	441	544	6440

The mineralization while not extensive, indicates base metal potential for Harbour Main Group mafic volcanic rocks in this area. Other base metal occurrences in the Harbour Main Group include the Oxley, Rusty Zone and Rusty Fault Zone prospects in the Cape Broyle area and minor veins in the Cape St. Francis area. The distribution of the occurrences indicates that base metal mineralization is associated with the mafic phase of Harbour Main volcanism and warrants further investigation.

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THE STRUCTURAL EVOLUTION OF THE EASTERN MARGIN OF THE CENTRAL APPALACHIAN MOBILE BELT, NEWFOUNDLAND

R.E. Holdsworth[1], S.J. O'Brien[2], P.P. O'Neill[2], G.R. Dunning[3], R. Tucker[4]

SCOPE AND AIMS

Most of the existing tectonic models of Newfoundland suggest that the Gander - Avalon Zone contact represents a major terrane boundary, and imply that major strike-slip fault displacements have occurred in this region during the Palaeozoic or earlier. This project, initiated earlier this year, is intended to have a duration of 3 to 4 years and it aims to concentrate on four geological problems pertinent to the terrane boundary model:

a) The age, kinematic history and importance of the Dover - Hermitage Bay fault system.

b) The distribution and nature of late Precambrian orogenesis in the western Avalon Zone (the 'Avalonian') and its control on the formation of later Paleozoic structures.

c) The age, geometric and kinematic history of orogenesis in the eastern Gander Zone.

d) The nature and controls of magmatic emplacement mechanisms within the eastern Gander Zone.

SUMMARY OF FIELDWORK IN 1990

Field studies concentrated on well-exposed coastal sections around the Gander - Avalon boundary zone in northeast Newfoundland (Figure 1). Detailed structural mapping was carried out in Freshwater Bay*, Hare Bay*, Shoal Bay*, Lockers Bay*, Indian Bay, Valleyfield, Cape Freels - Windmill Bight* and also around Square Pond (Figure 1). Samples for U - Pb dating were collected from the major metamorphic, plutonic and volcanic units of the Gander and Avalon zones in several of these areas (marked *). These data from the sampled units will provide a detailed chronological framework, which will underpin the observed structural, igneous and metamorphic sequences.

Preliminary conclusions arising from the first field study are:

a) The tectonic history of the Gander - Avalon boundary zone is dominated by transpression;

b) Early, ductile sinistral transpression affects broad regions on either side of the boundary, and is overprinted by both low-grade ductile and later brittle-dextral transpression in the immediate vicinity of the Dover Fault. Field data apparently indicates the kinematic sequence is common to both zones.

c) In the eastern Gander Zone, the early sinistral transpression is spatially associated with the broad complex zone of migmatization and granite emplacement. Many granites are apparently emplaced into active sinistral shear zones based on observed field relationships.

d) In the western Avalon Zone, the belt of Love Cove Group adjacent to the Dover Fault is apparently younger than the

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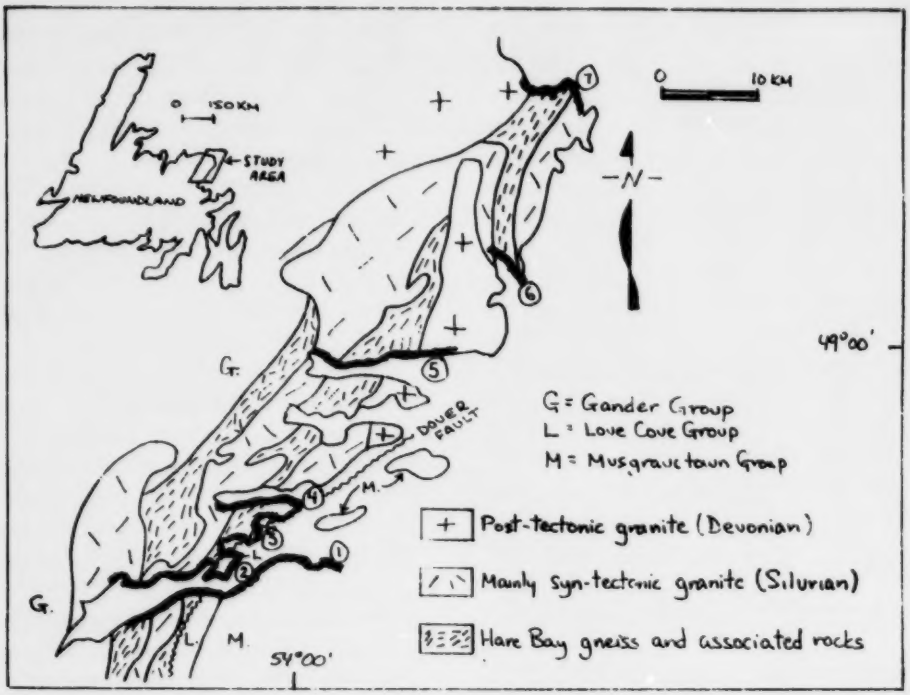

Figure 1. Simplified geological map of the field study areas; 1 = Freshwater Bay, 2 = Hare Bay, 3 = Shoal Bay, 4 = Locker's Bay, 5 = Indian Bay, 6 = Valleyfield, 7 = Cape Freels - Windmill Bight.

Musgravetown Group. If this observation is correct, this belt of volcanics cannot be equivalent to the 620 Ma (pre-Avalonian) Love Cove Group further east. Some revision of the western Avalon tectono-stratigraphy is therefore probably necessary.

U - Pb dating, which will commence later this year, will provide independent tests of these preliminary hypotheses.

INTEGRATION AND INTERPRETATION OF GEOCHEMICAL DATA FROM GRANITOID ROCKS OF INSULAR NEWFOUNDLAND: ACTIVITIES DURING 1990

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Newfoundland Mapping Section

PROJECT OVERVIEW

This project was established to compile, integrate and release geochemical data collected by the Geological Survey Branch from granitoid plutonic rocks throughout insular Newfoundland. The primary objective is to make this data available in a processed form to interested researchers and explorationists. A parallel objective is to develop and participate in multidisciplinary projects aimed at developing a better understanding of the petrogenesis and mineral potential of these suites in the wider framework of Appalachian orogenic evolution.

Data from mapping projects compiled since 1972, comprising some 4000 analyses, were initially compiled into a large SPSS-X computer file (Butler, 1988). Some limited field work was carried out during the 1989 field season (Kerr, 1989) to provide data from unrepresented plutonic suites and initiate a reference collection of "representative" samples for use in isotopic and mineralogical studies. Activities during the latter part of 1989, and in early 1990, were limited to some preliminary interpretative work, re-analysis of sample populations from the 1970's and some small-scale field work in the Placentia Bay area.

INTERPRETATION OF DATA

Much work remains to be done to validate and organize the granitoid geochemistry database, and to make it fully representative. However, even in its present preliminary form, the database is a valuable investigative tool. Some preliminary interpretative work was conducted in early 1990, with emphasis on late- to post-orogenic granites of Siluro-Devonian age, and an overview paper on the geochemistry of these suites was presented in Vancouver (Dickson *et al.*, 1990). A written summary was included in the proceedings of the 1990 Lithoprobe East transect meeting (Kerr *et al.*, in press). Revisions to preliminary classifications of Hayes *et al.* (1987) and Williams *et al.* (1989) were suggested on the basis of geochemical data. During the course of this work, it was recognized that much of the geochemical data collected during early projects, (e.g., Strong *et al.*, 1974) is inadequate for application of current classification and petrogenetic modelling techniques, which rely heavily upon trace-element geochemistry. Accordingly, plans were made to re-analyse pre-1978 sample populations.

RE-ANALYSIS OF OLDER (pre-1978) SAMPLE POPULATIONS

The survey of Strong *et al.* (1974) represented the first application of large-scale geochemical and statistical methods to Newfoundland granites. Although some areas have subsequently been assessed in far greater detail (e.g., the Ackley Granite, by Dickson, 1983), for many plutonic suites in eastern Newfoundland, the 1974 dataset remains the only significant source of geochemical information.

Data presented by Strong *et al.* (1974) were acquired mostly by XRF techniques at Memorial University of Newfoundland. The trace-element analysis suite was relatively limited, consisting

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* Transferred to Newfoundland Mapping Section.

of Zr, Sr, Rb, Zn, Cu, Ba, and F. Uranium was subsequently determined by Davenport (1978) using neutron-activation (INAA) methods. In contrast, recent Geological Survey Branch mapping projects utilize a combination of atomic absorption (AA), inductively-coupled plasma emission (ICP) and other analytical techniques. Most of this work is conducted at the Department of Mines and Energy laboratory, and precision and accuracy of analysis is monitored much more rigorously than was the case in the early 1970's.

In order to assess the reproducibility of data from the Strong *et al.* (1974) survey, 50 powders were randomly selected for full repeat analyses. Results suggest that, although some major elements (e.g. SiO_2, Al_2O_3) and trace elements (e.g., U, Cu) appear reliable, the data reproducibility for others is highly variable. Secondly, present analytical techniques allow expansion of the trace-element suite to include a range of economic elements (e.g., Mo, Li, Be, Ag) and also trace elements that are crucial in modern interpretative methods (e.g., Ga, Nb, Th). In view of the importance of the 1974 survey as a data source, it was decided to re-analyse the entire sample population to upgrade data quality to levels comparable to those of more recent projects. This was completed in September 1990, and the data is now ready to be added to the database. A few samples could not be re-analysed due to missing or insufficient powdered material.

Some other early geochemical surveys, notably that of DeGrace *et al.* (1974) for northeastern parts of the Baie Verte Peninsula, suffer from the same deficiencies. Re-analysis is also planned for this and other older sample populations. However, problems have been encountered in locating the original powders from these projects.

ISOTOPIC STUDIES

Under the auspices of the LITHOPROBE EAST supporting science program, multiple isotopic studies of Newfoundland granitoid suites have been conducted by Brian Fryer and co-workers at Memorial University of Newfoundland and elsewhere. Work to date has emphasized neodymium and oxygen isotope geochemistry, and has been based upon samples archived from mapping projects. Preliminary results have been summarized by Fryer *et al.* (1989).

Samples collected during the 1989 field season (Kerr, 1989) will form an important part of this long-term project, and are currently being prepared for isotopic analysis at Memorial University. ICP-MS analysis of samples collected in 1989 for REE and other trace elements has been completed, and it is hoped that 1991 will see a significant expansion of the isotopic database.

FIELD WORK IN THE PLACENTIA BAY AREA

Several, small intrusions exposed on Placentia Bay islands were examined. They are believed to be of Devonian age, and thus represent the most easterly expression of Appalachian plutonism in Newfoundland. In order of areal extent, these are the Red Island Granite (Hogg, 1954), the Ragged Islands Intrusive Suite (O'Driscoll and Muggridge, 1979), the Sall the Maid Granite (O'Driscoll, 1976) and the Iona Islands intrusions (McCartney, 1955). The only age determination is a K - Ar (biotite) result of 390 ± 30 Ma (Leech *et al.*, 1963), from a granite on Iron Island, which was correlated with the Red Island Granite. There is thus no definitive evidence that other examples are actually Paleozoic; however, with the exception of parts of the Sall the Maid Granite, all appear undeformed.

These intrusions are petrologically variable. The largest body, the Red Island Granite, is dominated by pink, leucocratic, biotite granite that is locally quartz-porphyritic. It is associated with a prominent aeromagnetic anomaly, suggesting that it is part of a much larger plutonic body. Disseminated pyrite occurs in

Cambrian sediments adjacent to its contact, and is associated with skarn-like contact metamorphic assemblages. The Ragged Islands Intrusive Suite ranges in composition from a melanocratic granodiorite to a pink, miarolitic leucogranite that is locally vuggy, and was probably emplaced at high crustal levels. The Sall the Maid Granite probably consists of at least two discrete units; a hornblende-bearing granodiorite (which is locally foliated) is dominant, but this is locally intruded by a pink, equigranular, alaskitic leucogranite, that shows evidence of high-level emplacement. The Iona Islands Intrusions are dominated by massive gabbroic rocks that are invaded by numerous granite dykes and sills, and exhibit many spectacular intrusion breccia and stoping textures. The granite phase is consistently younger than the gabbro, but the rounded shapes of some mafic inclusions suggests that the age difference may not be great. Tourmaline - quartz patches (locally of a vuggy nature) suggest both high emplacement levels and strong differentiation. Some of the granites resemble those observed on Red Island.

Although of minor extent, these possible Paleozoic granitoid rocks have potentially great importance as "windows" through which the nature of basement rocks to the Avalon Zone might be obtained via isotopic studies. The Red Island Granite was sampled by Strong *et al.* (1974), but relatively little is known about the others. All were examined and sampled during 1990, and a brief discussion of their petrology and geochemistry is planned for the 1991 current research volume. Verification of their age is obviously also required, and the idea of supporting an honours thesis project to conduct Rb-Sr geochronology on some of the samples is being explored.

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CAMBRO-ORDOVICIAN PLATFORMAL ROCKS, GOOSE ARM, WESTERN NEWFOUNDLAND

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The Goose Arm area, a well-exposed tract of fairly well known but poorly understood rocks, is part of the Lower Paleozoic miogeocline in western Newfoundland. Two months of reconnaissance field work, defined the lithostratigraphy within its regional framework, and determined the age and correlation of parts of this stratigraphy. The basic structural relationships of the deformed platformal sequence are however less well understood.

All the rocks in the area are probably parautochthonous. They are assembled in a stack of thrust slices and include clear facies changes from slice to slice, particularly in rocks of Cambrian age. Lithostratigraphic sectioning combined with a careful search for fossils has enabled the correlation of inter-thrust lithostratigraphy and set the succession within the regional stratigraphic framework of western Newfoundland.

RESULTS

Cambrian Lithostratigraphy

The oldest unit in the lowest structural position in the area is the Penguin Cove Formation. A mixed, generally shallow subtidal carbonate - siliciclastic sequence, its lower part is correlated with the Bridge Cove Member, Hawke Bay Formation of Canada Bay (Knight and Boyce, 1987). It contains fossils of early Middle Cambrian age. The overlying upper part is late Middle Cambrian oolitic - oncolitic limestones that correlate with the March Point Formation (Chow and James, 1987). It is in turn succeeded by a thick succession of dolostones and limestones that correlate with the Petit Jardin and Berry Head formations (Chow and James, 1987). A middle limestone member in the Petit Jardin Formation contains fossils of Dresbachian age. Trilobites from the top of the Berry Head Formation indicate a latest Cambrian to Earliest Ordovician age for the youngest strata.

The oldest succession in easterly structural slices, the Reluctant Head Formation of ribbon limestone and phyllite plus resedimented limestone conglomerate beds is a ramp-slope sequence. It has yielded *Bolaspidella* to *Crepicephalus* zone trilobites of latest Middle to early Upper Cambrian age. This indicates a correlation with lower Petit Jardin Formation. The formation is overlain by a shoaling succession of dolostones that include carbonate-sand shoal and tidal-flat facies. This suggests that the Lower Paleozoic carbonate shelf initially evolved as a prograding ramp for considerably longer than suggested by evidence in co-eval allochthonous sediments of the Cow Head Group (James and Stevens, 1986).

Ordovician Lithostratigraphy

Ordovician carbonates of the Goose Arm area have been previously placed within the Corner Brook Formation. Preliminary work shows that the 4-fold division of the St. George Group (Knight and James, 1987) and the limestones of the Table Head Group (Stenzel *et al.*, 1990) mapped elsewhere in western Newfoundland occurs in the area. Like other parautochthonous sequences in western Newfoundland (Knight, 1986, 1987), there is considerably less dolomitization than in autochthonous areas. Consequently, dolostones that host base metal deposits such as at Daniel's Harbour appear to be thin or absent in the area.

Structure

Although the study is still in its infancy and no systematic mapping has occurred it appears that the area is characterized by a west-verging thrust stack complicated by later east-verging structures. The west-verging structures dominate lower structural levels and east-verging structures higher slices that lie adjacent to the the Humber Arm and Old Man Pond allochthons. Intensity of deformation increases towards the sole of each thrust. For example, within the Reluctant Head thrust zone, early west-verging structures include transposed bedding with recumbent F1 folds. The phyllite-carbonate folia (S1) are in turn folded about co-axial F2 and F3 recumbent and sheaf folds indicative of progressive deformation within the thrust zone. East-verging folds and cleavage steepen and crenulate earlier structures. Large recumbent, east-verging folds deform the earlier planar fabric of carbonate-phyllite schist in areas adjacent to the Old Man Pond Allochthon. Relationships near the Humber Arm Allochthon (Penguin Head) are complex. Here, complexly folded rocks of the upper St. George Group and the Table Head Formation structurally lie upon upper Table Head Group and Goose Tickle flysch (possibly a mélange) that is downfaulted against middle St George Group strata to the east.

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REGIONAL GEOLOGY OF THE NEW BAY AREA (PARTS OF 2E/6 AND 2E/11), NOTRE DAME BAY, NEWFOUNDLAND

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The New Bay area in central Newfoundland is underlain by both the Notre Dame and Exploits subzones of the Dunnage Zone. In 1990, geological mapping of this area has resulted in some new insights that deal with, most notably, the paleontology of the Lower Paleozoic strata, the facies relations in the alternating belts of volcanic and sedimentary rocks, the tectonic analyses of Notre Dame and Exploits basins, and the mineralization history and intrusive sequence in the Dunnage Zone slate belts. These points highlight the importance of the relative positioning of successive depocentres and the repetitive patterns of fault-controlled emergence, features that ultimately bear on the regional relationships within and between the Dunnage subzones, and on their respective mineral potential.

The distribution of the lithostratigraphic units in the New Bay area is shown in Figure 1. Although all of the stratified rocks are regionally metamorphosed to chlorite or lower grades and have abundant primary features, some of the map units in the area are distinctly unfossiliferous or are solely composed of undated volcanic, hypabyssal and plutonic rocks. The Mortons Harbour Group, the South Lake Igneous Complex, the Cottrells Cove Group and the Wild Bight Group (units 1-4, respectively) are of unknown age and, with the possible exception of the upper boundary of the Wild Bight Group exposed on the coast of New Bay (Figure 1), all of these units display tectonic contacts. Detrital clasts derived from the Wild Bight Group and possibly the South Lake Igneous Complex occur in Ashgillian strata in the New Bay area. This observation provides the only known stratigraphic constraints on map units 2 and 4, although the upper part of the Wild Bight Group probably correlates with the pre-Caradocian sedimentary rocks in the central and eastern parts of the region.

In the New Bay area, dated lithostratigraphic units range from Llanvirn to Llandovery in age (Figure 1). From oldest to youngest, they are the Exploits Group, the Lawrence Harbour Shale, the Point Leamington Greywacke and the Botwood Group (units 5-8, respectively). In places where sandy and shaly flysch predominate over volcanic deposits, these marine fossil-bearing units are at least 4 km thick, if measured together. The order of superposition of the three oldest units, discernible from locally preserved stratigraphic contacts, corroborates their absolute age assignments. Furthermore, they indicate that the Exploits Group (base not exposed), the Lawrence Harbour Shale (base and top exposed) and the Point Leamington Greywacke (Goldson Conglomerate lithofacies included; top not exposed) comprise a conformable, Llanvirnian - Ashgillian succession (S.H. Williams, personal communication, 1990), which is widespread throughout the New Bay area. In the western part of the Bay of Exploits (Figure 1), marine strata of Ashgill-Llandovery age (W.D. Boyce, personal communication, 1990; S.H. Williams, personal communication, 1990) are tentatively assigned to the Botwood Group (unit 8), although stratigraphic relations with any of the other Ashgillian or older units have yet to be firmly established. Mafic volcanic rocks, with or without contemporaneous felsic volcanic rocks or thin limestones, are present at several stratigraphic intervals in the Llanvirn-Llandeilo (and older?) Exploits Group and the Llandovery (and younger?) Botwood Group, but are conspicuously absent from units of intermediate age.

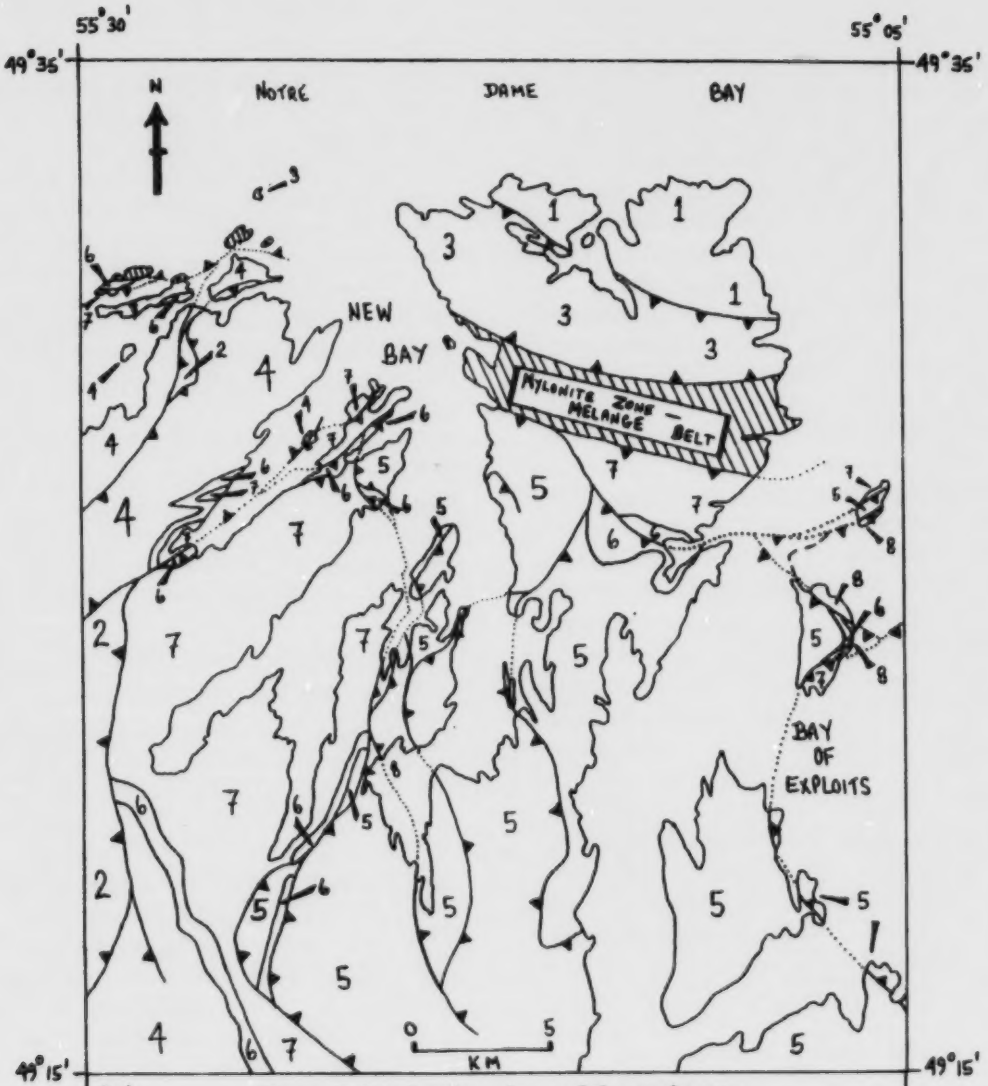

Figure 1. Regional geology of the study area.

LEGEND

SILURIAN AND ORDOVICIAN

Ashgill-Llandovery

8 Botwood Group

Ashgill

7 Point Leamington Greywacke
(includes Goldson Conglomerate)

Caradoc

6 Lawrence Harbour Shale

Llanvirn-Llandeilo

5 Exploits Group

ORDOVICIAN OR EARLIER

4 Wild Bight Group

3 Cottrells Cove Group

2 South Lake Igneous Complex

1 Mortons Harbour Group

Most of the brittle-ductile fault zones in the New Bay area are situated along the flanks of anticlinoria and synclinoria, and occur near the margins of the major sedimentary and structural basins within the Exploits Subzone. However, the largest total strains were produced along the mutual boundary of the Notre Dame and Exploits subzones in a 2- to 3-km-wide mylonite zone (Figure 1), which includes the discontinuous melange belts of the Boones Point Complex. During the imposition of a low-grade slaty cleavage of unknown age or ages, the fault zones in both subzones initially developed as gently-inclined to steeply-dipping thrusts. Subsequent inhomogeneous deformation, witnessed chiefly by the folding of the thrust faults and the kinking of the regional foliation to form cleavage arcs, is most evident within the narrow fault zones themselves, where the imbricated lithostratigraphic units are recrystallized but not thoroughly mylonitized. Although some of the large thrust sheets are bounded by domed thrusts (Figure 1), it is unlikely that this outcrop pattern originated by folding faults that had one, regionally consistent sense of thrust polarity. Rather, thrust faults that formed concomittantly with anticlinoria and synclinoria may have originally developed inclined in more than one direction. Post-slaty cleavage overfolding and strike-slip faulting of thrust faults is, however, an observable feature of the major fault zones.

In several locations in the New Bay area, slump-folded greywackes and iron-rich cherts display complex stratigraphic relationships with submarine volcanic rocks, which locally host cupriferous stockworks and silicic alteration zones. Pre-Caradocian units in the sedimentary-dominated belts and volcanic-dominated belts intertongue along and across strike in the vicinity of some of the major fault zones. There, such units are seen to be affected by abrupt facies changes and thickness variations. Periodic emergence and localized uplift may have occurred near tectonic hinge lines situated along basin margins, themselves isostatically controlled by synsedimentary and synvolcanic faults. Certain parts of the New Bay area are possibly underlain by condensed Llanvirn-Llandeilo successions and, therefore, may have been starved of the sedimentary and volcanic deposits that accumulated by relatively accelerated modes of deposition in adjacent parts of the region. In the lower parts of the Exploits and Cottrells Cove groups, thick sequences of pillow lavas are capped by thin discontinuous horizons of felsic tuffs and associated cherts, which pass laterally into proximal greywackes. The positions of the felsic rocks of these volcanic belts relative to the volcanogenic wackes and plutonic boulder conglomerates of the sedimentary belts may not only have important implications for base-metal mineralization but may also indicate the presence of large, Ordovician or earlier fault scarps.

Basin-margin faults are the preferred loci of a suite of undated, syntectonic intrusions. Those hard-rock faults that bound or affect the Exploits Group, the Cottrells Cove Group, the Wild Bight Group and the Mortons Harbour Group contain a greater variety and a larger abundance of composite mafic-felsic and multiple mafic, syntectonic intrusions than do those developed in the Lawrence Harbour Shale, the Point Leamington Greywacke and the Botwood Group. This may indicate that syntectonic intrusive suites are preferentially emplaced into dilatant structures such as anticlinal hinge zones or the hanging walls of thrust faults. Alternatively, the major ductile fault zones may be linked to syndepositional faults and, therefore, utilize the conduits in the dominantly volcanic rock belts that characterize the pre-Caradocian successions. Regardless of origin, the composite gabbro - diorite - diabase sheet intrusions are variably foliated and altered; the periods of deformation, alteration and contact metamorphism being bracketed by the various members of the intrusive suite. Fault zones that yield evidence of a protracted history of mafic intrusion followed by leucogranite or quartz feldspar porphyry are particularly good targets for exploration, especially in the Exploits Subzone.

SILURIAN COVER, LATE PRECAMBRIAN - EARLY ORDOVICIAN BASEMENT, AND THE CHRONOLOGY OF SILURIAN OROGENESIS IN THE HERMITAGE FLEXURE

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Redefining the La Poile Group as an Early - Late Silurian terrestrial volcanosedimentary succession and establishing its external relationships has led to its recognition as a cover sequence developed upon a basement complex (see Figure 1). Basal La Poile Group conglomerate rests nonconformably on Late Precambrian basement granite, which crosscuts undated high-grade amphibolitic gneiss and low-grade sedimentary and volcanic rocks. This composite sub-La Poile Group basement also contains early Paleozoic plutonic constituents the youngest of which is Early Ordovician in age), which delimit discrete pre-Silurian tectonothermal events within the complex. Early Silurian granites, which are in part synchronous with the accumulation of subaerial cover deposits, are restricted to the sub-La Poile basement and have been affected, in places, by mesozonal synplutonic shear zones. Later

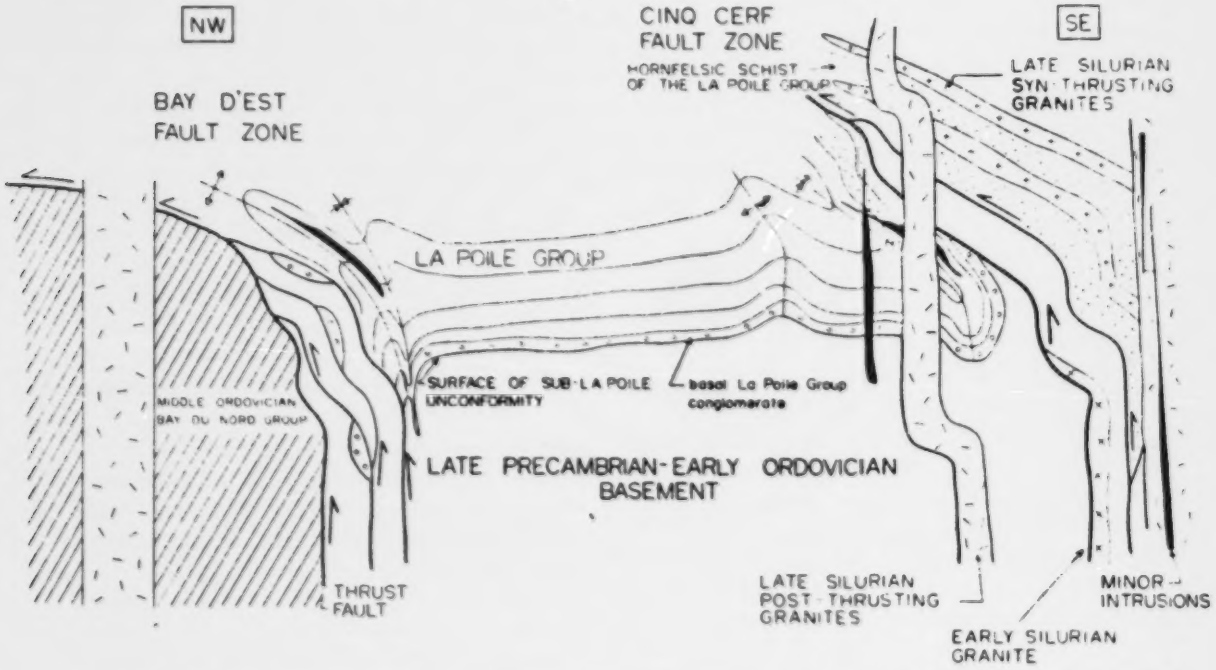

Figure 1. Schematic cross-section showing relationships amongst the La Poile Group, the sub-La Poile basement and Silurian intrusions. Footwall of the Bay d'Est Fault Zone may also include minor, unseparated, pre- and post-Middle Ordovician rocks.

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Silurian plutons were emplaced syntectonically during regional deformation and dynamothermal metamorphism of the Silurian cover and contemporaneous remobilization of its basement. Thrust imbrication of cover and basement, which was preferentially sited along the fault zones that bound the La Poile Group, occurred shortly after deposition, prior to the emplacement of Late Silurian granite porphyry. The older Silurian granites and the thrust-imbricated assemblage of basement and cover are crosscut by Late Silurian granite plutons; all have been affected by further inhomogeneous ductile deformation that predates the posttectonic intrusion of Early Devonian granite.

The Silurian La Poile Group and its underlying Late Precambrian - Early Ordovician basement delimit the southern extent of the Dunnage Zone in the southwest Hermitage Flexure region of the Newfoundland Appalachians. The sub-La Poile basement and its cover, both of which overthrust Dunnage Zone rocks, were variably deformed and metamorphosed during a climactic Silurian orogeny sited along the southeastern crystalline margin of the Newfoundland Central Mobile Belt.

GEOLOGY OF THE SOUTHEAST GANDER LAKE AREA (NTS 2D/15) AND SOUTHWEST GAMBO MAP AREA (NTS 2D/16)

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Newfoundland Mapping Section

The southeast corner of the Gander Lake map area (NTS 2D/15) and the southwest corner of the Gambo map area (NTS 2D/16) were mapped during the 1990 field season (see Figure 1). The area lies within the Gander Zone and the work is a continuation of a bedrock mapping project initiated in the northwest part of this zone in 1986. Two rock units predominate in the map area, the Gander Group and the Gander Lake Granite. Exposure is sparse throughout the area, being considerably less than 1 percent.

The Gander Group is poorly exposed and consists of interbedded psammite, semipelite and pelite. Primary structures are generally absent due to the effects of penetrative deformation and metamorphism. Pelitic and semipelitic rocks of the Gander Group are texturally variable being hornfelses in the contact aureole of the Gander Lake Granite, whereas they are schistose in the west where they are intruded by leucocratic, garnetiferous muscovite granite. In the Butts Pond and Square Pond area and farther east toward the Middle Brook Granite, the pelitic and semipelitic rocks are also schistose.

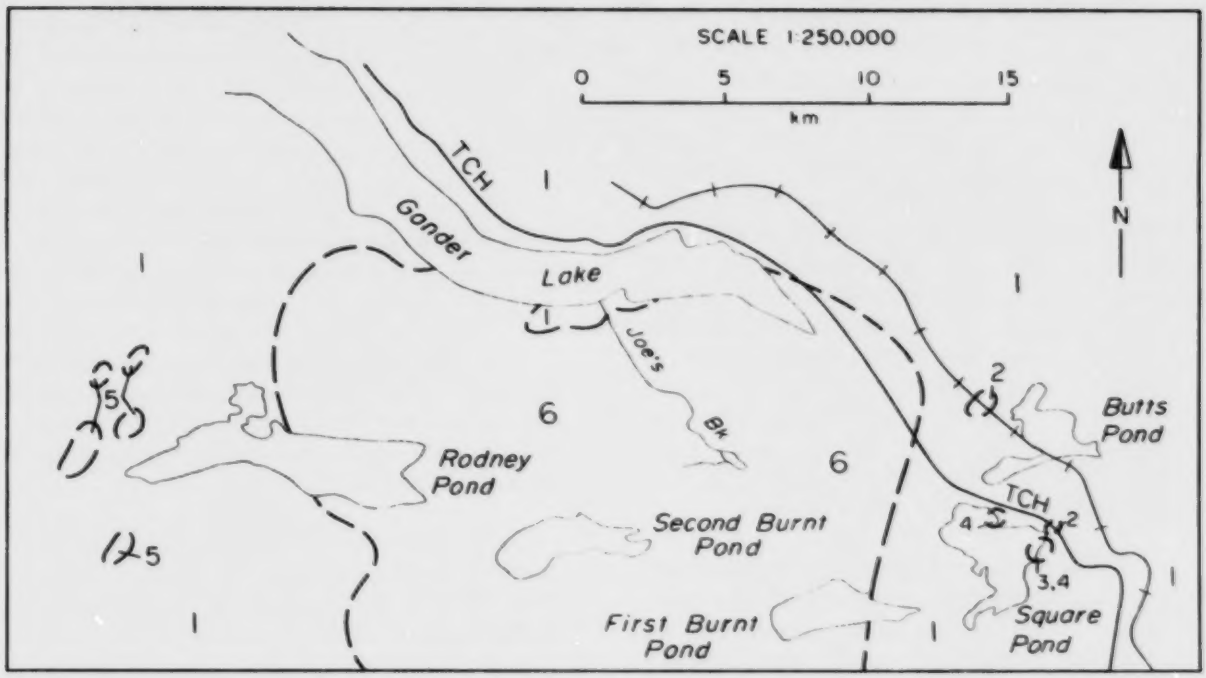
The Gander Lake Granite underlies approximately two thirds of the map area. It is megacrystic and biotite-rich throughout much of its exposure. In one outcrop north of Rodney Pond, the granite is equigranular and coarse grained, and megacrysts occur sparsely. The megacrysts generally show a random arrangement but along the northeast margin of the granite, on the shores of and near Gander Lake where exposure is good, a primary east-west flow foliation is present. This foliation is approximately parallel to the margin. The megacrysts are K-feldspar, range up to 8 cm long and typically form approximately 50 percent of the rock. The granite is homogeneous as observed in the sparse exposures and extensive boulder fields. Locally, tourmaline is a primary phase in the granite but it occurs more commonly in pegmatitic veins near the margins.

In the western part of the area, small bodies of a leucocratic muscovite granite intrude the Gander Group. This granite is garnetiferous and tourmaline-rich particularly in pegmatitic parts and biotite occurs rarely.

Several small granitic and gabbroic bodies occur in the Square Pond area. East of Butts Pond, several exposures of an equigranular, medium-grained, biotite muscovite granite occur. Granite exposed on the north shore of Square Pond is leucocratic and muscovite-rich and both granite and gabbro which occurs in association with the granite, are heterogeneously foliated.

Altered ultramafic rocks occur in two exposures in the map area. One outcrop adjacent to the old railway line 1 km west of Butts Pond is completely altered to an assemblage of serpentine, talc and minor carbonate. A penetrative foliation developed in the rock is parallel to the regional foliation. The second ultramafic body is exposed in a roadcut on the Trans-Canada Highway, immediately north of Square Pond and occurs in tectonic contact with psammite and semipelite of the Gander Group. The rock appears altered to serpentine and carbonate predominantly and is talcose in the sheared margins.

Rocks of the Gander Group exhibit one main phase of deformation producing isoclinal folds, which are overprinted locally by second phase tight folds. In the Square Pond and Butts Pond area, these rocks and the small bodies of gabbro and granite are affected by a steep, high-



LEGEND

Siluro – Devonian

6 Gander Lake Granite: *Megacrystic, K-feldspar biotite granite.*

5 *Equigranular, leucocratic garnetiferous, muscovite granite.*

4 *Muscovite + biotite granite.*

3 *Gabbro*

Ordovician or Older

2 *Altered ultramafic rock.*

1 Gander Group
Jonathans Pond Formation: *Interbedded psammite and greyish green pelite, minor quartzite, quartz granule sandstone and mafic intrusive bodies. Metamorphosed to lower amphibolite grade adjacent to granitoid bodies.*

Figure 1. Geology map of southeast Gander Lake and southwest Gambo area.

strain foliation, approximately parallel to the regional foliation. The phyllonites immediately northeast of Square Pond, locally contain a metamorphic mineral assemblage characterized by andalusite, kyanite and sillimanite. This structural/metamorphic zone can be correlated with a similar zone along strike to the northeast in the Gull Pond - Wing Pond area. Preliminary examination of kinematic indicators in the high-strain rocks indicate dextral shear.

GEOCHEMISTRY/GEOPHYSICS

MULTI-USE GEOCHEMICAL MAPS OF NEWFOUNDLAND AND LABRADOR

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Regional geochemical surveys have involved, historically, the determination of a small suite of elements, chosen to meet limited objectives (mineral exploration and resource appraisal) and constrained by analytical problems and costs. Recent advances in analytical chemistry, which have made feasible the determination, at low unit cost, of over 40 elements to levels below their Clarkes, are revolutionizing geochemical mapping by removing many of the analytical constraints, thereby allowing a single survey to serve the needs of both general geological and environmental studies, as well as those of mineral exploration much more satisfactorily.

The archived regional drainage sediment sample set covers the entire province (organic lake sediment for most of the province, with stream sediment from the Torngat Mountains of northernmost Labrador). Lake sediment from Newfoundland is being re-analyzed systematically in two stages to expand the element suite from the initial, limited, 11 elements (Ag, Co, Cu, F, Fe, Mn, Mo, Ni, Pb, U, and Zn) plus loss-on-ignition, to add, firstly, Au, As, Ba, Br, Ce, Cr, Cs, Eu, Hf, La, Na, Rb, Sb, Sc, Se, Sm, Ta, Tb, Th, W and Yb by multi-element neutron activation analysis (NAA), and, secondly, Al, Be, Ca, Cd, Ga, K, Li, Mg, Nb, P, Sr, Ti, V, Y and Zr by ICP optical emission spectrometer (ICP).

Progress of the re-analysis program in Newfoundland to November 1, 1990, is shown in Figure 1. For the NAA suite, results for NTS sheets 1M, 1N, 2D, 2E, 11O, 11P, 12A and 12H have been released (Table 1), as well as for parts of 12B (1-3), and 12I (1). Analysis of samples by ICP is underway for NTS sheets 2E, 11O and 12H, and the results will be released on open file

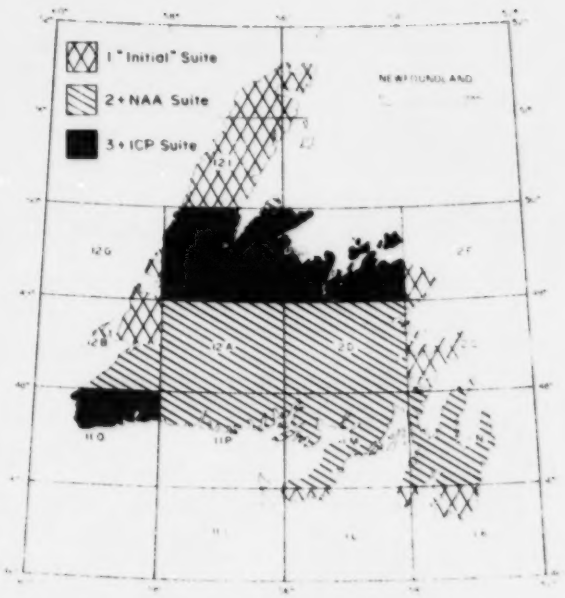

Figure 1. Index map showing element suites determined for regional lake sediment samples in Newfoundland: 1 initial suite (Ag, Co, Cu, F, Fe, Mn, Mo, Ni, Pb, U, Zn and LOI); 2 initial suite plus NAA suite (Au, As, Ba, Br, Ce, Cr, Cs, Eu, Hf, La, Na, Rb, Sb, Sc, Se, Sm, Ta, Tb, Th, W and Yb); and 3 initial suite plus NAA suite plus ICP suite (Al, Be, Ca, Cd, Ga, K, Li, Mg, Nb, P, Sr, Ti, V, Y and Zr).

in 1991. In Labrador, lake sediment from NTS sheet 13O and parts of sheets 13J, 13K and 13N in eastern Labrador, and the Labrador portions of 23I, 23J and 23O in western Labrador have been re-analysed for the NAA suite and the results released (Hornbrook and Friske, 1988, 1989).

The results for gold and associated elements have stimulated mineral exploration in

Table 1. List of open files for gold and associated elements by neutron activation analysis (NAA) in regional lake sediment for insular Newfoundland

NTS Area(s)	Open file	Release date	Reference
11O (all) 12H/9-11,15,16 12I/1	Nfld. 1582	1987-09-24	Davenport and Nolan, 1987
2E (all)	2E/563	1988-08-02	Davenport and Nolan, 1988
2D (all)	2D/175	1988-11-01	Davenport et al., 1988
1M/5,11-16	1M/276	1989-02-14	Davenport et al., 1989a
11P (all)	11P/137	1989-03-29	Davenport et al., 1989b
12H (all)	12H/1012	1989-06-06	Davenport et al., 1989c
12A/1-4,8 12B/1-3	Nfld. 1801	1989-07-11	Davenport et al., 1989d
1M (all)	1M/312	1990-05-30	Davenport et al., 1990a
12A (all)	12A/561	1990-08-28	Davenport et al., 1990b
1N (all)	1N/499	1990-09-18	Davenport et al., 1990c

the province by identifying new target areas of potential gold mineralization. In addition, the NAA data contain considerable information on the natural variations in background level of several elements that are either essential or toxic to plants and animals, and the list of environmentally important elements is further increased by the ICP suite. The initial surveys and the reanalysis projects have been supported, since 1973, by the Governments of Canada and Newfoundland and Labrador through a series of Mineral Development Agreements, and the geochemical mapping program will continue in both Newfoundland and Labrador under the new Mineral Development Agreement.

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ON THE JOINING, CORRECTION, GRIDDING AND INTERACTIVE VGA DISPLAY OF THE REGIONAL AEROMAGNETIC DATASET (GSC) FOR INSULAR NEWFOUNDLAND

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Geochemistry and Geophysics Section

This report describes, briefly, the steps taken to prepare the gridded, digital-aeromagnetic dataset for Newfoundland and, an interactive computer routine designed to display the contents of gridded datafiles as images on a VGA monitor. The various display modes of the program allow a fairly rapid and thorough examination of the features contained in the gridded datafiles.

Aeromagnetic flight-line profile data, originally digitized from 1:63,360 scale (1"=1 mile) paper plots by the Geological Survey of Canada (G.S.C.), for all of onshore Newfoundland and Labrador have been joined into contiguous survey blocks in order to reconstruct the vintage surveys that comprise the dataset. In the process, a rigourous and thorough process of error checking and correction has been performed on the data. Data from several map sheets were distorted, and these therefore required "rubber-sheeting", to correct the geographic coordinates before being joined. The data were then iteratively checked for digitizing errors through a cyclical process of creating gridded datafiles from the profile data, viewing these as shaded-relief images, verifying features against the paper plots of the data and effecting corrections to the digital profiles. Following this, the data from the various surveys were levelled to minimize distortions along their mutual boundaries and thus to produce an homogeneous and seamless dataset, from which relatively error-free gridded data can be interpolated for any area.

Gridded datafiles were created with a grid cell size of 200 m for each of some 18, 1:250,000 scale NTS map areas for insular Newfoundland. Directional, wave-number domain Butterworth filters were then applied to the grids to optimaly remove the next largest source of error remaining in the dataset: the offset or levelling error between adjacent flight line profiles. Other post-processing procedures included trimming the grids to include only the grid cells that are situated within each NTS map area, and calculation and inclusion of a frequency histogram of the distribution of aeromagnetic values contained within each grid-file.

All geographic coordinates were converted, before gridding, to Universal Transverse Mercator (UTM) projection using a central meridan of 57°W longitude (UTM zone 21). Corrected data-grids have been created for insular Newfoundland and are being made available to the public in the form of a digital Open File, on floppy disks, in two popular grid-storage formats: GEOSOFT™ and GEOPAK™. The correction and levelling of the dataset for Labrador is continuing.

An IBM compatible interactive display program, DISPLAY, was written to display gridded datafiles as various images on a VGA monitor, and is included at no extra cost with each order of the gridded data. DISPLAY will enable the user to interactively view either a single grid or two grids as images on a split screen in either of the following modes: 0-63 grey-scale intensities, 0-63 grey-scale shaded relief, 253 rainbow colours (unshaded), or total-colour shaded relief. The user can make changes interactively to a menu of parameters, which independently control the display of the grid files, including the name and/or number of files displayed, azimuth and declination of false illumination (shading), decimation or scaling

factor, histogram equallized colour-scaling or linear colour stretching between a user-input minimum/maximum, or mode of display. DISPLAY is compatible with any gridded datafile stored in either the GEOSOFT™ or GEOPAK™ grid formats. An accompanying user's manual fully documents the various display options available to the user.

OVERBANK- AND STREAM-SEDIMENT SURVEYS ON THE BAIE VERTE AND SPRINGDALE PENINSULAS

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Geochemistry and Geophysics Section

During the summer of 1990, a geochemical sampling program was conducted over portions of the Baie Verte and Springdale peninsulas (Figure 1). Samples of overbank sediment and active stream sediment were collected from areas that were regarded as having good mineral potential. The sampling areas were selected on the basis of favourable lake-sediment data (Davenport and Nolan, 1987, 1988) and prospective geological attributes. The purposes of the survey are two-fold: to further evaluate the mineral potential of the area by providing geochemical data complementary to existing lake-sediment, geophysical and geological data and, secondly, to develop the application of overbank surveying in Newfoundland. The project is part of an ongoing overbank/stream sediment program begun last year in the Hermitage-Bay D'Espoir area (McConnell and Honarvar, 1989).

Since 1864, the Baie Verte Peninsula has been a focus of mining. Numerous gold and base-metal occurrences are known, several of which are currently being evaluated for possible production. The peninsula is divided tectonostratigraphically by the Baie Verte Line - a structural break between the Humber Zone to

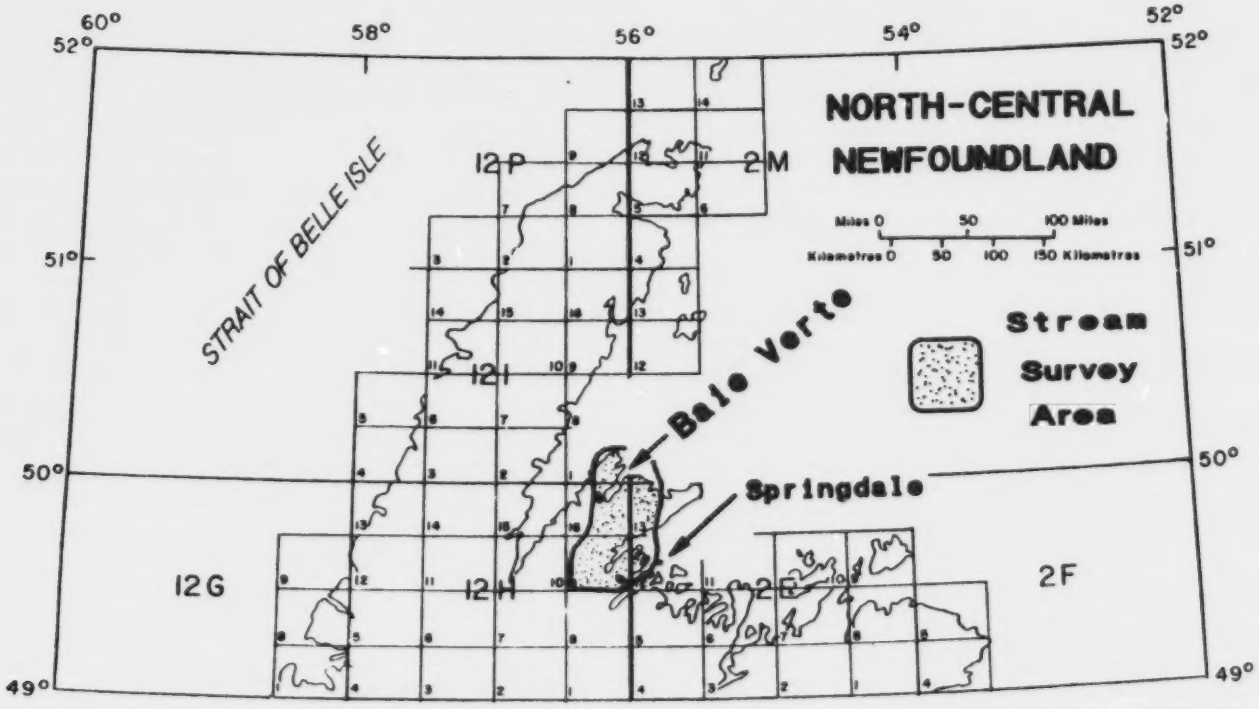

Figure 1. Location of overbank and stream sediment survey.

the west (dominantly schist, gneiss and granitoids) and the Dunnage Zone to the east (dominantly ophiolite). The survey area in the Springdale Peninsula is underlain mostly by Cambrian ophiolitic rocks of the Lushs Bight Group and Ordovician volcanic and epiclastic rocks of the Western Arm Group (Kean and Evans, 1987 and 1990). These units host many volcanogenic massive sulphide deposits including past producers and epigenetic gold occurrences. The various regions of the field area are classified geochemically, using contoured regional lake-sediment data, as being enriched in one or more of three element groupings: a gold association (Au, As,Sb and/or Se), a mafic association (Cu, Cr, Ni and/or Pb) and a granophile association (Ce, Pb, Ta and/or Yb). Pleistocene glaciation left most of the area with a covering of locally derived colluvium or a thin till veneer. Stream sediment and overbank is likely dervived from a combination of such glacial material and actively eroding bedrock.

Samples were collected from streams having upstream catchment basins on the order of 2 to 6 km^2. Where possible, a stream-sediment and overbank sample were obtained at the same site. Approximately 200 to 300 g of <300 μ sediment were obtained by wet-sieving material on-site. Samples of overbank material were collected in Kraft paper soil bags. Samples of <63 μ sediment and overbank material will be analyzed for a large suite of elements including Au, As, Sb, base metals, Fe, Mn, and a range of rare earths, W and other lithophile elements. Heavy-mineral concentrates will be prepared from overbank/sediment site-pairs and analyzed as described above.

An open file report on the 1990 study will be released in the coming year.

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TERRAIN SCIENCES

QUATERNARY MAPPING IN THE GANDER AREA (NTS 2D/15)

Martin J. Batterson and Spencer Vatcher
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Quaternary mapping of NTS map sheet 2D/15 (Figure 1) was undertaken to provide data on the surficial geology, the types and distribution of Quaternary sediment, and develop an ice-flow history for the area. This data could be used for a number of geoscientific, engineering and planning applications. In particular, the generation of a model that explains the glacial history of the area could be applied to drift-exploration problems encountered during mineral exploration in those parts of the area with a heavy drift cover.

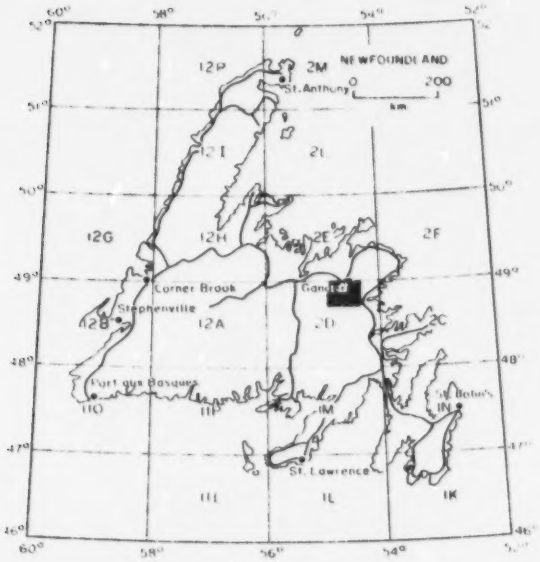

Figure 1. Location Map, Gander map sheet.

The field area is mainly composed of a monotonous assemblage of psammitic and semi-pelitic rocks of the Gander Group. A pink megacrystic granite, and a foliated two-mica granite are found south of Gander Lake. To the west are metasediments and volcanic rocks of the Davidsville Group. Ultrabasic rocks of the GRUB line occur in faults between the Davidsville and Gander groups. Mineralization is commonly associated with this zone, and has, in recent years been the focus of gold exploration.

Previous reconnaissance-level mapping of ice-flow indicators indicates that two major flow events affected the area. The first was an eastward flow from a probable source in the Red Indian Lake area; the second was a north- to northeastward-flow-event, probably from the Maelpaeg Lake area. Field work this summer has generally supported the regional ice-flow model, although the influence of Gander Lake is now considered to have had more of an affect on the late phases of ice movement than previously thought.

The field area can be roughly subdivided into 3 distinct geomorphic areas. To the north of Gander Lake, the surficial terrain is dominated by bedrock. Quaternary sediment cover is thin and discontinuous. Transport distances for glacial diamictons are likely short, i.e., < 1 km. The western part is dominated by glaciofluvial and fluvial sediments associated with meltwater flowing out of the Gander and Southwest Gander River valleys, northward through the modern-day outflow. Sediments are sandy gravels with sub-rounded to well-rounded clasts, indicative of long transport distances (> 5 km) within a fluvial system. Outwash sediments are also associated with valleys in other parts of the area. The area between Gander Lake and Rodney Pond, and the area northeast of the community of Gander is dominated by a sediment cover generally greater than 3 metres thick; bedrock outcrops are rare. The sediment is a glacial diamicton of probable basal origin. It has a moderately compact, silty to fine sandy matrix and contains clasts of dominantly local origin; exotic clasts have a westward provenance. The sediment is fissile,

and contains irregularly-shaped lenses of sand, which are deformed under, and draped over clasts. Fabrics show a strong north-south orientation, with S_1 values of greater than 0.7. These characteristics are generally consistent with a basal melt-out till. A surface capping of large clasts is common, possibly representing a supraglacial sediment cover.

Initial conclusions suggest that the Gander map area has a complex glacial history. The area has been affected by at least 2 major flow events. From clast provenance studies, and identified Mount Peyton granite clasts, it is clear that the early eastward flow deposited sediment across the area. However, the fabric data suggests that the final sediment-moving phase was northward, although transport distances are unknown.

DETAILED AND RECONNAISSANCE SURVEYS IN THE BULL ARM - MOSQUITO COVE AREA, TRINITY BAY AND IN CENTRAL NEWFOUNDLAND

Dan Bragg
Terrain Sciences Section

The 1990 field season was divided into two programs. The first was a detailed investigation of the Bull Arm - Mosquito Cove area, Trinity Bay (Figure 1). This assessment was carried out to determine the quality and quantity of bedrock in the area for potential use in the construction of gravity-based concrete platforms. The second was an evaluation of the bedrock-aggregate potential of quarries and roadcuts between Grand Falls and Baie Verte Peninsula (Figure 1). This assessment was undertaken to determine the quality and quantity of bedrock aggregate available for local use.

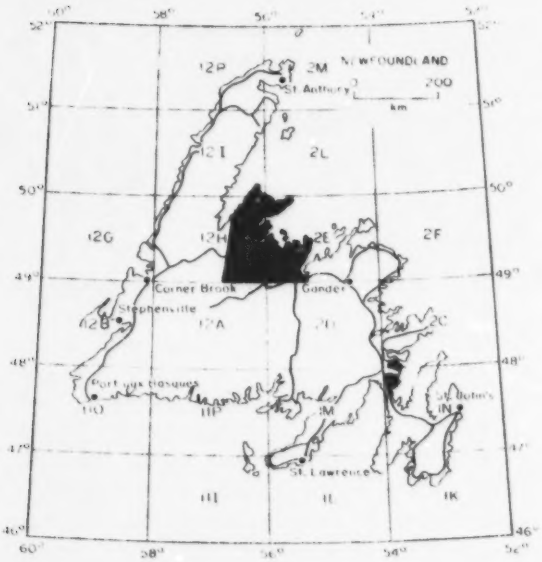

Figure 1. Field areas - bedrock-aggregate assessment projects, 1990.

The first five weeks of the field season were centred in the Bull Arm - Mosquito Cove area of Trinity Bay. Field survey work consisted of boat and foot traverses along the coast. Field investigation for each site consisted of identification of rock types, overburden thickness, degree of weathering, geological structures present, and type of mineralization and alterations.

A total of 57 sites were visited in this area and 51 samples were taken. Of the 57 sites visited, 18 sites are considered to be high potential for concrete aggregate sites.

The second half of the field program centred in the Grand Falls to Baie Verte peninsula area in central Newfoundland. Field work consisted of traverses along highways and side roads and visiting all the rock quarries in vicinity. The field investigation for each site is the same as that for the Bull Arm - Mosquito Cove area.

A total of 509 sites were visited in this area and 270 samples were taken.

Along with the field investigation, a laboratory investigation consisting of petrographic analyses, petrographic number and thin - section work was also undertaken. Laboratory testing will be carried out on selected samples and will consist of Los Angeles Abrasion, Magnesium Sulfate Soundness and Alkali - reactivity.

DETAILED AGGREGATE-RESOURCE ASSESSMENTS, INSULAR NEWFOUNDLAND

F.T. Kirby
Mineral Lands Division
Mineral Resource Management Branch

During the 1990 field season, aggregate-resource assessments were done in eight areas throughout the province. The aim of the assessments were to identify areas of high-quality aggregate, protect these valuable non-renewable resources from conflicting land uses, and so make them available to meet the long-term aggregate requirements of the region. The eight areas of study were, (1) Bull Arm, (2) Northern Arm, (3) Grand Falls, (4) Kings Point, (5) Pasadena/South Brook, (6) Raleigh, (7) Holyrood (8) Shoal Harbour (Figure 1).

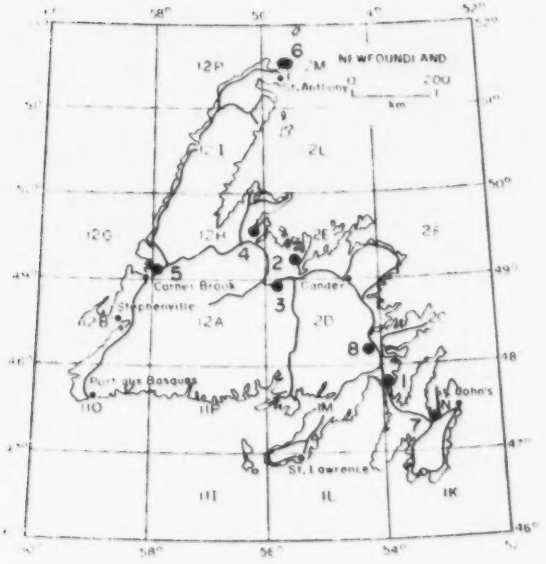

Figure 1. Location map of assessment areas.

A total of 134 aggregate samples were collected from natural and man-made exposures and from backhoe test-pits, where required. Field sieve and petrographic analysis have been completed on all samples. Laboratory sieve analysis on all samples collected is nearing completion.

PRELIMINARY RESULTS

(1) Bull Arm

Field work in this area was divided into two parts. The first part involved the sampling of bedrock throughout the Bull Arm area to assess its potential to supply crushed bedrock aggregate for use in the construction of the Gravity Based Structure (GBS) at Great Mosquito Cove. (Bragg, this volume). The second phase of field work involved a surficial aggregate survey of the area within a 30 km radius of Great Mosquito Cove. The only significant deposit of sand and gravel in the area is located at North West Brook. It is a deltaic deposit composed of stratified sand and gravel; a total of 10 samples were collected for analysis. Preliminary results indicate that the deposit may be suitable for use in the GBS development, but the volumes of material available may not be sufficient to meet the total requirements.

(2) Northern Arm

A backhoe test-pitting program was conducted in an existing quarry within the Community of Northern Arm to determine the quality and extent of the deposit. A total of 10 backhoe test-pits were dug and sampled. A test-pit location map and preliminary sample results have been forwarded to the Department of Municipal and Provincial Affairs to assist them in developing a detailed extraction and rehabilitation plan for this deposit, so it can be incorporated into a Municipal Plan for the community.

(3) Grand Falls

The Grand Falls survey is a continuation of a survey begun in 1989. A backhoe test-pitting program was conducted in a sand and gravel deposit 23 km west of Grand Falls. A total of 31 test pits were dug and 31 samples collected. Preliminary results indicate that this deposit has the potential to supply high-quality concrete aggregate to the Grand Falls regional market area.

(4) Kings Point

This survey was undertaken to identify areas within the Kings Point-raised-delta-system that are available to meet the present and future aggregate needs of the area. The locations of conflicting land uses were mapped and the location of potential aggregate areas were sampled. A total of 13 samples were collected and analysis of these samples has been completed.

(5) Pasadena - South Brook

The work in this area concentrated on locating sources of sand and gravel suitable for use in the re-construction of the Trans-Canada Highway through the Pasadena area. The study concentrated on the South Brook valley, which begins at Grand Lake and enters Deer Lake at South Brook. Sampling throughout the valley included 16 backhoe test-pits, however material suitable for road construction was not found. The results of the study also indicated that sand and gravel deposits located in the Pasadena - South Brook area are generally found below 60 m subsurface.

(F) Raleigh

A re-evaluation of the aggregate-resource zones, within the Raleigh Municipal Planning area, has shown that the zones previously identified, are confined to thin veneers of (<1 m) oxidized sand over bedrock. As a result of this re-evaluation, all aggregate zones previously identified within the Raleigh Municipal Planning area have been eliminated. Work done on Burnt Islands has identified several areas of raised marine beach sand and weathered dolomite that make good sources of aggregate for concrete production for local use. A total of six samples were collected and analysis is presently nearing completion.

(7) Holyrood

A backhoe test-pitting program in an area to the north of the area sampled in 1989 has been completed. A total of 14 test pits were dug and 14 samples were collected. Preliminary test results indicate that the material is similar to that sampled previously. Therefore, the known limit of the aggregate reserves in the Holyrood Access Road area have been extended further to the north and thereby increasing the available reserves in the area substantially.

(8) Shoal Harbour

A backhoe test-pitting program was conducted in the Shoal Harbour Pond quarry area to determine the extend and quality of the remaining aggregate reserves in the area. A total of 17 test pits were dug and 17 samples were collected for analysis.

All sample data will be available when laboratory sieve analysis is completed.

QUATERNARY GEOLOGY OF THE SPRINGDALE MAP SHEET (NTS 12H/8)

David Liverman, Sharon Scott and Howard Vatcher
Terrain Sciences Section

The Springdale map sheet is located in north-central Newfoundland (Figure 1). This project was initiated to better define the Quaternary geology of the area. Knowledge of the surface sediment physical properties is important in drift exploration techniques, aids in location of aggregate resources, provides information relating to slope stability, and helps in determining suitability of surficial sediments for groundwater, and waste disposal sites.

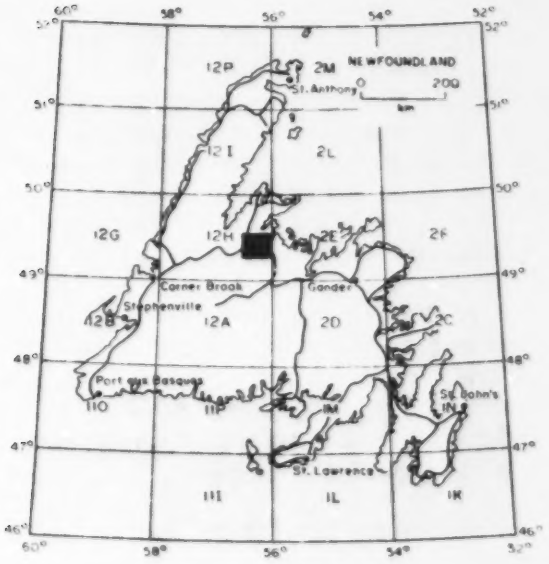

Figure 1. Location map.

Surficial maps of the areas were made by Grant (1973, 1986). Alley and Slatt (1975) discussed the glacial geology and sediment dispersal in the Sheffield Lake - Indian Pond area, identifying two tills, an "upper grey till" and a "lower red till" interpreted as lodgment tills deposited by separate advances. Tucker (1973, 1974) outlined extensive marine deposits in coastal areas, with a marine limit defined at 75 metres above sea level. These are described by Scott and Liverman (this volume).

Access to the area is excellent due to the numerous logging roads built in the last thirty years. Most of these roads are still in good condition, and were traversed using truck or all terrain vehicles. Close to three hundred sites were described in detail, including over 100 striation sites, and 16 backhoe pits. 60 clast fabrics were obtained from well-exposed sections and backhoe pits.

RESULTS

Ice Flow

Striations and clast fabrics are interpreted as showing a simple ice flow history over the south and west of the map sheet, with a single major ice flow from the Topsails, parallel to the major valleys of Burnt Berry Brook, West Brook, Barney's Brook, and South Brook. This results in a flow pattern converging on the low of Hall's Bay, which appears to have acted as a major outlet/conduit of ice away from central Newfoundland. Most multiple striation sites are found close to the coast and indicate a two-phase ice-flow history, with initial flow parallel to Hall's Bay (northeasterly), and a subsequent flow towards the bay (northwestern or eastern). Combining these results with other striation mapping in the area (Liverman and St. Croix, 1989; Liverman and Scott, 1990) suggests that following intial flow from a major ice centre located over the area of the Topsails, minor ice centres were established as deglaciation commenced. One centre was probably located on the southern or central Baie Verte Peninsula, or on the southern Northern Peninsula. Flow from

this centre was across the southern Baie Verte peninsula towards Hall's Bay.

Surficial sediment

Sediment cover over the area is variable. The coastal areas to the north and northeast have comparatively little surficial sediment cover on high areas, with bedrock intermittently exposed. The valleys, however, have a thick surficial fill, related to marine incursion following deglaciation (Scott and Liverman, this volume). Large gravel bodies up to 75 m thick were deposited as ice-contact deltas at the mouths of the South Brook, West Brook, Burnt Berry and Indian Brook valleys. Smaller gravel deltas are found at lower elevations as far as 20 km inland from the present coast. Close to the coast, outwash and marine gravels are underlain by well-sorted marine clay and silt, up to 20 m thick.

Numerous meltwater channels are found on the slopes of the West Brook, Indian Brook and Burnt Berry valleys, suggesting that at the time of their formation, the valley bottoms were deglaciated, and ice remained on the ridge tops supplying meltwater. The hummocky topography found to the southwest of the map sheet suggests passive meltout of ice in this area, and sediments examined in section show abundant evidence of meltwater, removing clay and silt from the till, and forming sorted interbeds of sand and gravel. This is supported by generally poorly oriented clast fabrics in this area. A surface bouldery veneer is found over much of the area, up to 1 m thick, and probably originated as supraglacial meltout.

Till Stratigraphy

Backhoe pits in the area that was studied by Alley and Slatt (1975) did not confirm a multiple till stratigraphy. Although more than one diamicton unit was found in several pits, the stratigraphic relationships were not consistent, and the diamictons did not show the characteristics of lodgment tills, particularly in that only weak clast fabrics were found. Sections in the Hall Hill area contained a poorly consolidated diamicton with weak clast fabric overlain by a highly consolidated diamicton having a strong clast fabric. This is interpreted as lodgment till overlying basal melt-out till, and implies either a late readvance or tills deposited in distinct glacial events.

CONCLUSIONS

Using drift prospecting techniques over much of the area will require considerable care, but should prove effective. Sampling in particular must be planned to avoid areas reworked by meltwater, and samples must be taken below the bouldery surface veneer. Clast fabric studies should be used where possible to supplement striation data for ice flow, and to aid in the identfication of basal tills. The extensive gravel deposits associated with marine incursion are significant aggregate resources, and may well be the source of groundwater supplies. These areas, however, are very poor areas for any type of waste disposal site, and, given that most communities are situated on or close to these deposits, care is required in the siting of dump sites. The marine clays may be a useful source of clay for brick making (e.g., Ricketts, 1987), but may be unstable in any road construction.

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GRANULAR AGGREGATES IN CENTRAL AND NORTHEASTERN NEWFOUNDLAND (NTS 2E/3, 4, 6 AND 11)

M.J. Ricketts and J. McGrath
Terrain Sciences Section

As part of a continuing study of a 1:50,000 regional aggregate-resource mapping program in Newfoundland, several sand and gravel deposits were sampled to provide material for grain size and petrographic analyses, soundness and abrasion test. The field area is situated in the Botwood (2E/3), Hodges Hill (2E/4), Point Leamington (2E/6) and Exploits (2E/11) map area of central and northeastern Newfoundland (Figure 1). The objectives of the program are to locate, map and sample all sand, gravel and sandy-till deposits. These deposits are excellent sources of low silt-clay materials which are necessary for use in concrete, asphalt and road construction projects.

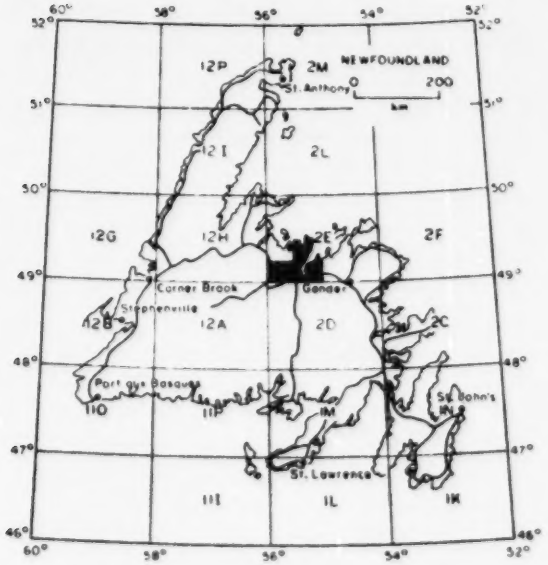

Figure 1. Location of study area.

Field work was conducted in a manner similar to that by Kirby *et al.* (1983). Interpretation of 1:50,000 scale black and white aerial photographs was used as a guide to locate potential resource areas. Following this, interpretation of coloured aerial photographs at 1:12,500 scale was conducted in selected areas based on deposit type, to delineate deposit boundaries more accurately. Field sampling was carried out at 0.5- to 1.0-km intervals in outwash deposits, and at 1.5- to 2-km intervals in till. Additional samples of granular material were taken wherever sediment-type changes were observed, where quality differences were measurably apparent, or wherever sediment of variable quality or texture occurred together that could be mined separately. Backhoe testpitting was conducted in selected areas, where other exposure types were not present, to obtain material for analyses and to determine deposit extent.

A total of 261 sites were examined and 222 samples were collected. Field sieving and petrographic analyses were done on 203 samples (samples which contained material greater than +16 mm in diameter). Field sieving was done by using a bank of four 30-mm-diameter brass sieves with mesh sizes of 63, 31.5, 16 and 8 mm. Approximately 500 gm of material passing the 8 mm sieve was retained for further laboratory sieve analysis. Pebbles in the plus 16 to 32 mm range were retained for lithologic and petrographic identification.

Several sand and gravel deposits were mapped and sampled in the study area. These deposits are situated near the mouth of the Exploits River, Jumpers Brook, Southwest Brook, Norris Arm, Kite Cove, Peters River, Northern Arm Brook and Northern Arm in map area 2E/3; Cornfield Pond, Aspen Pond and Hodges Hill in map area 2E/4; Porterville, Point Leamington and New Bay River in map area 2E/6.

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ICE FLOW IN THE BAY OF EXPLOITS AREA, NEWFOUNDLAND

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Terrain Sciences Section

INTRODUCTION AND OBJECTIVES

The 1990 field season, focusing on the Bay of Exploits region of Newfoundland, is a continuation of work from the 1988-89 field seasons.

The objective of the project was to compile reconnaissance level maps of glacial striae, at a 1:50,000 scale, of NTS map sheets 2E/2, 3, 6, 7, 9, 10 and 11 and the east half of 2E/5 and 5 (Figure 1). Striation mapping is an effective method of obtaining a broad understanding of the general ice-flow history, over a wide, regional area.

RESULTS

Approximately 425 single and multiple striation sties were observed and recorded during the field season. Ice-flow direction can be determined from the morphology of the bedrock surface using such features as stoss and lee, nailheads and chattermarks. Sites that indicate more than a single ice-flow direction suggest either multiple separate flow events or possibly differing ice-flow directions within one flow event. Relative temporal relationships between the flows are indicated by crosscutting characteristics and leeside preservation.

The data collected suggests a complex ice-flow history in the area with evidence of three or more separate ice-flow events over all or part of the region. The first and earliest ice-flow direction trends east southeastward and was found at several sites throughout the region. The second ice-flow direction was northward and was found mainly around the Bay of Exploits and to the east reaching all the way out to the coast with its path being affected by local topography. The third ice-flow identified had a north

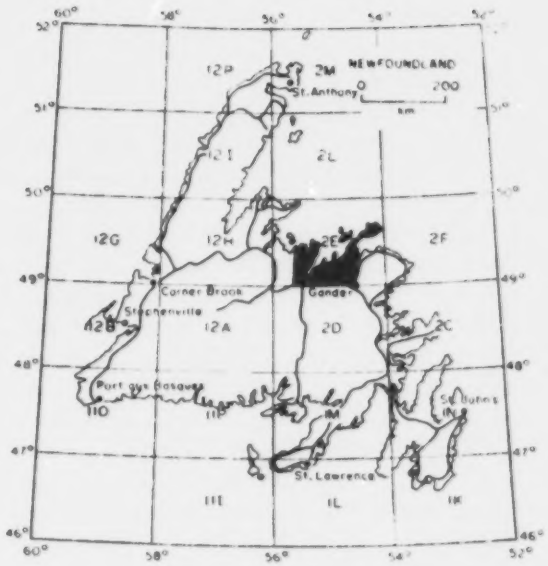

Figure 1. Location of study area.

northeastward trend and was found to the west of the Bay of Exploits. A possible fourth direction also observed to the west of the Bay of Exploits has an eastward trend. Its relationship to the eastward ice-flow mentioned earlier is unclear at this time.

IMPLICATIONS FOR DRIFT PROSPECTING

An understanding of ice-flow history of this region will aid mineral exploration when interpreting data derived from mineralized float or geochemical anomalies. In general, the most recent flow is expected to be associated with the occurrence of a geochemical anomaly or dispersal pattern. However, in this case where multiple flows have been identified, the earlier flows should be considered: 1) the earlier ice-flows of east and southeastward may have

initially dispersed the sediment before it was affected by the later north-northeast flow, and 2) most of the area has a thick drift cover and it is possible that a complex till stratigraphy exists over parts of the region. In such cases, provenance and thus geochemistry of each till sheet will differ, and care must be taken in sampling.

SUMMARY

This data, when combined with existing data to the west, (Hornbrook, *et al.*, 1975) and (Liverman and Scott, 1990) and to the south (Vanderveer and Sparkes, 1980) and (Taylor and St. Croix, 1989) and to the east (Vanderveer and Taylor, 1987), will help with the compilation of the ice-flow history for north-central Newfoundland. It is planned to extend this coverage over the coming years.

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SEDIMENTOLOGY OF MARINE DEPOSITS IN THE SPRINGDALE - HALL'S BAY AREA

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Terrain Sciences Section

INTRODUCTION

The study area is located in the Springdale-Hall's Bay area of Newfoundland lying between 56°15'W & 56°00'W and 49°32'N & 49°25'N (part of 12H/8 and 12H/9 topographic map sheets) (Figure 1). Following deglaciation of this area in the Late Wisconsinan, raised sea levels resulted in marine inundation of areas lying below 75 m above present sea level (Tucker 1973). The result is raised marine deposits along the shores of Hall's Bay. The sedimentology of these marine and coastal sediments may thus be easily investigated. The objectives of the marine deposit study were:

1) to describe marine sediments, particularly fine-grained rhythmically-bedded material, in order to determine environment, depositional mechanisms and modes of genesis.

2) to collect and describe fossils.

3) to integrate sedimentology, paleontology, and geomorphology to determine the history of sea level change.

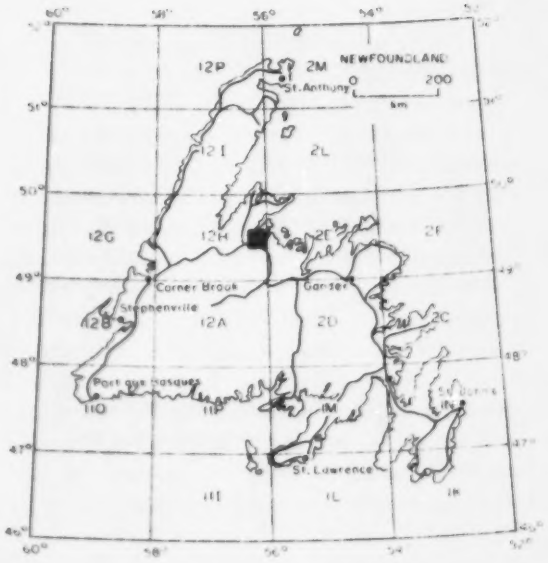

Figure 1. Location of study area.

PREVIOUS WORK

Richards (1940) mentioned that barnacles were found in red marine silts in the Springdale area. Maclintock and Twenhofel (1940) briefly described the large deltas at Springdale and South Brook as outwash that was deposited by meltwater from glaciers draining into Hall's Bay and were subsequently wave cut. Lundqvist (1965) described the deltas in more detail. Grant (1972) found shells in the Hall's Bay area and they were dated at 12,000 ± 220 years BP (GSC - 1733) (Tucker, 1974). Tucker (1973) described rhythmites of silt and sand in the Springdale area but was unable to determine if they were marine or lacustrine (Shells were found in gravels in South Brook by Tucker (1973) and were dated at 11 000 ± 190 years BP [Lowden and Blake, Jr, 1975]). Vanderveer (1977) described the clay deposit found near Springdale as varved with some lenses of silt and sand all of which is overlain by sand and gravel and identified it as a potential economic resource. In 1987 the Newfoundland Department of Environment and Lands were involved in the drilling of a well at Indian River Provincial Park. Samples taken from the initial blow-hole core (which went to a depth of 27.4 m) showed a sequence of sands and gravels with some clay 2 m below the surface. Liverman and Scott (1990) briefly described the clay found at the bridge over Indian Brook on the Springdale highway as a

well-sorted laminated and bedded silt and clay up to 10 m thick. The sediment contained a few scattered coarse clasts that were draped by the overlying sediment and the conclusion that the sediment was deposited in ice-distal glaciomarine environments was made. Surficial mapping of 12H/8 was undertaken in conjunction with this project (see Liverman, Scott, and Vatcher in this volume).

RESULTS

Three excellently exposed sections up to 31 m thick were discovered during reconnaissance showing dominantly well sorted laminated silt/clay/fine sand with the occasional dropstone. These sections showed various water escape and slump structures as well. The altitude of all sections were measured with an altimeter accurate to ± 5 m. Bivalve shells were found in all three sections and at one site, five different species of shell were found. Detailed description and sampling was undertaken throughout the sections and at all sites for sediment textural analysis, micropaleontology and geochemistry.

Exposures of sands and gravel with planer beds dipping at up to 26° were also found at 8 locations in the area. These sections were described but not sampled and current-direction indicators were measured where possible.

CONCLUSIONS

Initial results indicate that the clay sections represent marine incursion into the area as a result of higher sea level stands. These clays were deposited by suspension settling as well as by gravity flow (including slumping). The sections indicate increasing distance from the sediment source when moving east (shown by the increased clay content). Marine incursion was extensive through the Indian Brook and South Brook Valleys; reaching at least 12 km inland as shown by the material found in the park.

The shells gathered will allow an assessment of the marine environment in two ways: 1) chronology and 2) marine environment (salinity, turbidity, and paleotemperature). The sediment descriptions will aid development of a model for glaciomarine sedimentation in this area.

The sea-level history along with the sedimentology will enable some correlations with off-shore sedimentation. The grain-size of the clays is such that slope stability is a problem along the Indian Brook and any construction could be dangerous. But there is the possibility of an economic resource in the clays (Ricketts, 1987). Due to the large amounts of sands and gravels in the area care must be taken in planning location of municipal dump sites. Springdale and South Brook have their dumps located in sands and gravels and seepage of the material is likely to occur. In the case of South Brook any seepage would wash into the sea (possibly affecting the fishery in the area). The Springdale dump site is located approximately 15.2 m above sea level so seepage probably goes down 15 m to the clay and then runs along the clays to exit into Indian Brook (a major salmon river).

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MINERAL DEPOSITS

METALLOGENIC STUDY GOLD MINERALIZATION NORTHEASTERN DUNNAGE ZONE, CENTRAL NEWFOUNDLAND

David T.W. Evans
Mineral Deposits Section

INTRODUCTION

A metallogenic study of gold mineralization hosted by rocks of the eastern Dunnage Zone was initiated in the fall of 1989. Detailed mapping, sampling and core logging, undertaken during the 1990 field season, were confined to prospects located in the northeastern portion of the Dunnage Zone (Figure 1).

Gold mineralization was first discovered in the area, in 1978, during regional mapping by the Newfoundland Department of Mines and Energy. During the exploration rush of the late 1980's, Noranda Limited staked a large portion of the northeastern Dunnage Zone and subsequently, through a combination of regional prospecting and geochemical soil and lake sediment sampling, discovered a number of significant gold prospects and showings.

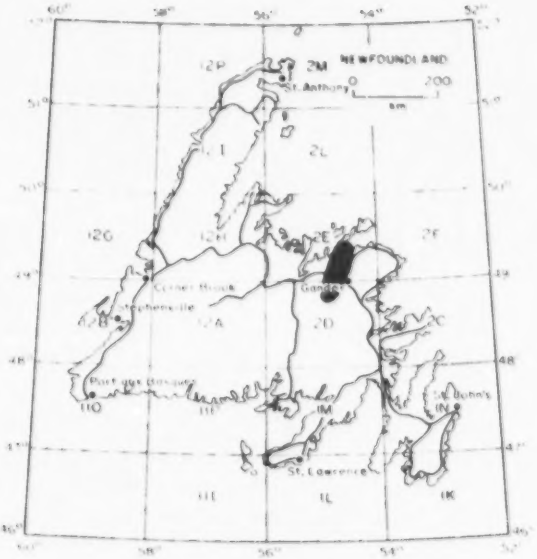

Figure 1. Location of study area.

REGIONAL SETTING

The northeastern Dunnage Zone comprises three major rock packages: the Lower Ordovician Gander River Ultrabasic Belt (GRUB Line), the Middle Ordovician Davidsville Group, and the Silurian Botwood Group. The rocks of the GRUB Line, interpreted to represent oceanic crust, are discontinuously developed along the eastern margin of the Dunnage Zone, and are unconformably overlain by distal turbidite sequences of the Davidsville Group. The Davidsville Group, in turn, is interpreted to pass gradationally upwards into fluviatile rocks of the Botwood Group.

GOLD MINERALIZATION

Gold mineralization within the northeastern Dunnage Zone is epigenetic and structurally controlled. The mineralization is widespread but does not appear to be confined to particular stratigraphic belts or groups. However, certain areas appear to be more prospective than others, particularly along or near the Davidsville - Botwood contact.

Initial results indicate at least five styles of gold mineralization are present within the study area:

1) Gold-bearing quartz carbonate veins, accompanied by intense Fe-carbonate alteration. These veins are developed within brittley deformed, small, sill-like gabbroic intrusions that appear to be localized along the Davidsville - Botwood contact. Coarse, free gold is locally developed in these veins.

2) Gold-bearing quartz veins hosted by carbonatized and silicified fine grained sedimentary rocks of the Davidsville Group.

3) Quartz veins developed in small shear zones that cut fine grained black shales of the Davidsville Group. These lack significant wallrock alteration. Minor alteration is confined to the more intensely deformed rocks within the shear zones. These vein systems locally contain spectacular coarse, free gold.

4) Brittley deformed greywacke units within the Davidsville Group host dilational quartz veins that contain minor gold values.

5) Epithermal style, low-grade gold mineralization is developed within the Davidsville Group near the contact with the Botwood Group. Spectacular hydrothermal breccias, coarse vuggy and chalcedonic quartz and intense argillic alteration denote this style of mineralization. This form of mineralization appears to be confined to the area south of Glenwood where the Davidsville - Botwood contact may be structural.

SUMMARY

Gold mineralization within the northeastern Dunnage Zone is epigenetic and structurally controlled. Preliminary work indicates that the gold mineralization is localized along second and third order structures that form a complex series of northeast-, north-northeast- and northwest-trending linears. These structures may have evolved in response to regional clockwise rotation of the structural elements of the Dunnage Zone as is documented elsewhere within the Dunnage Zone.

LIMESTONE ASSESSMENT ON NEWFOUNDLAND'S WEST COAST AND NORTHERN PENINSULA

Ambrose F. Howse
Mineral Deposits Section

The Lower Palaeozoic carbonate platform of western Newfoundland hosts important deposits of limestone, marble, and dolomite. Current production is confined to limestone deposits located at the southern end of the carbonate belt. Producers include the well-established cement manufacturing plant at Corner Brook (Northstar Cement), the newly developed, high-volume limestone aggregate quarry at Lower Cove on the Port au Port peninsula (Newfoundland Resources and Mining), and an agricultural limestone quarry at Cormack (Havelock lime). At the northern end of the belt, industrial attention has focussed on high purity white marble deposits in the Roddickton area, where significant quarry development has taken place on deposits at Coles Pond and near Croque (Aurion Minerals). Other companies engaged in marble assessment in the Canada Bay area include English China near Penny's Pond and Omya at Canada Harbour. Recent work by the Newfoundland Department of Mines and Energy has focussed on limestone deposits, especially those of potential commercial interest in the Middle Ordovician Table Head Group. Earlier assessment work drew attention to commercially attractive limestone deposits in the Northern half of the belt, yet stressed their then isolation as a serious impediment to development. The improvement in infrastructure on the Northern Peninsula since these surveys were conducted, and emerging new applications for which Newfoundland limestone may have competitive advantages, suggest that the resource should be re-examined. Figure 1 shows the survey sites for 1990 and the following prospects were investigated during the 1990 field season.

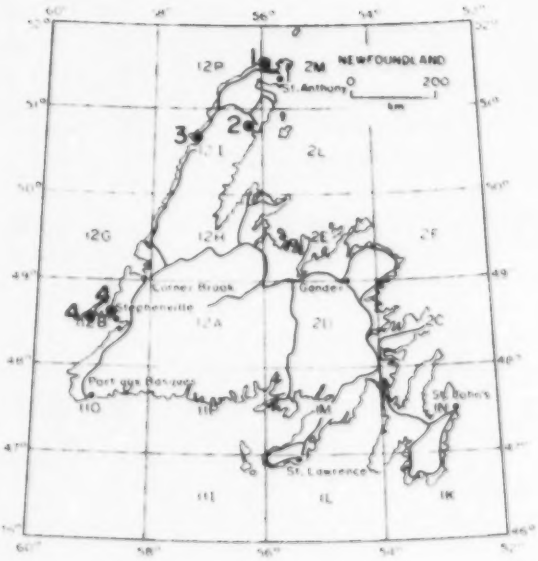

Figure 1. Location of study areas: 1. Cook's Hbr. - Raleigh, 2. Canada Bay, 3. Port au Choix, and 4. Port au Port.

Raleigh (Burnt Island)

One of the most commercially attractive limestone deposits in the province underlies Burnt Island, near Raleigh. Burnt Island is in fact a peninsula connected by a natural land bridge to Raleigh. This isthmus also supports a road that provides easy access to all parts of the deposit. Burnt Island and Raleigh form a natural harbour that can probably handle large ships although ice is a problem in winter and early spring. Limestone of the Lower Ordovician St. George Group comprises the approximate western half of the island, whereas Middle Ordovician limestone beds of the Table Head Group form the eastern half. The Table Head limestone is grey with a tint of brown, and contains numerous white calcite veins and stringers. It has a fine to medium crystalline texture. Overburden is virtually absent and all of the island's east side is extremely well suited topographically, for quarrying. Preliminary assessments consisting of

detailed surface sampling indicate that this deposit may be especially suited for a number of industrial applications including cement manufacturing and (or) aggregate production. The deposit was also sampled to test its suitability as a reagent for flue gas desulphurization in fossil-fuel energy systems. The results of similar analyses carried out on Table Head limestone samples collected in 1989 from the Port au Port Peninsula were very promising and indicate a potential additional use for the stone in pollution control systems.

Cook's Harbour

Detailed surface sampling was carried out on Table Head limestone, just north of Cook's Harbour, where thick fossiliferous beds outcrop continuously along the shore and inland. The limestone is dark grey, has a crystalline texture and is extensively veined by thin irregular stringers of calcite. Some thin argillaceous seams are also present. In some areas the rock has been intensively weathered to a thin mantle of pebbles and cobbles. The deposit is accessible by sea via Cook's Harbour, a sheltered port. Samples, systematically collected across the northern extremity of the deposit between Cook's Point and Bonne Cove, are being analyzed to determine the chemical purity of the limestone. A representative sample was also taken for FGD tests.

Other Prospects

Limestone prospects on the Port au Port Peninsula, near Port aux Choix, and north of Beaver Arm, Canada Bay were also investigated and sampled. A total of 172 chip samples were collected for geochemical analyses. A additional 30 larger samples were taken from selected sites for FGD tests. The results will be released on open file when they become available.

RARE METAL POTENTIAL IN INSULAR NEWFOUNDLAND

Randy R. Miller
Mineral Deposits Section

Recent work on the rare-metal mineralization in the Strange Lake Zr-Y-Nb-Be-REE deposit (Miller, 1986, 1990) and in the Letitia Lake Nb-Be±Y showings (Miller 1987) has lead to the development of a model for rare-metal mineralization associated with felsic rocks (Miller, 1988). This model will be applied to felsic-rock settings in Labrador and insular Newfoundland in a four year program to evaluate the rare-metal potential and to encourage exploration activity for rare metals in the province. This past summer, the first field season of the project, focussed on insular Newfoundland.

Targets include felsic volcanics and related intrusive rocks from complexes that are peralkaline, have peralkaline affinities (e.g., high values of Zr, Nb, U, F, REE) or are associated with peralkaline rocks. Complexes or suites targeted for sampling this summer (Figures 1 and 2) included: Hare Hills peralkaline granite, Topsails Intrusive Suite (including felsic volcanics of the Sheffield Lake area), the Kings Point Complex, the Cape St. John Group and the associated Seal Island Bight peralkaline granite, the Micmac Lake Group, the Musgravetown Group, particularly the Bull Arm Formation and associated Louil Hills peralkaline granite, the Mooring Cove Formation felsic volcanics (English Harbour East area), the Cross Hills Complex and the St. Lawrence Peralkaline Granite and the related volcanic - subvolcanic complexes (Grand Beach Complex, Rocky Ridge Complex, and Winterland Complex). All target suites were sampled and reconnaissance mapped except the Hare Hills, Topsails and Sheffield Lake suites; these suites will be sampled next summer. The sampled areas can be characterized as follows:

Kings Point Complex - A felsic subvolcanic-volcanic complex which consists of peralkaline and non-peralkaline trace-element enriched granites, porphyries, porphyritic syenite, ash flows, lava flows and breccias.

Seal Island Bight peralkaline granite - Riebeckite-bearing peralkaline granite.

Cape St. John Group - Rhyolitic flows, pyroclastics and ash-flow tuffs; also includes Cape Brule quartz-feldspar porphyry.

Micmac Lake Group - Volcanic - sedimentary sequence consisting of mafic flows, conglomerate, felsic ignimbrite and porphyry, and trachytic flows.

Bull Arm Formation - Mafic flows, rhyolitic flows and ash-flow tuffs.

Louil Hills peralkaline granite - Riebeckite-bearing fine- to medium-grained peralkaline granite.

Mooring Cove Formation (English Harbour East area) - Rhyolitic flows, flow breccia and ash-flow tuffs.

Cross Hills Complex - Aplitic, fine grained and medium grained peralkaline granite.

St. Lawrence Peralkaline Granite - Porphyritic and medium grained granite, quartz-feldspar porphyry, and amphibole syenite.

Grand Beach Complex - Quartz-feldspar porphyry, rhyolitic flows and ash-flow tuffs.

Rocky Ridge Complex - Quartz-feldspar porphyries.

Winterland Complex - Quartz-feldspar porphyry and porphyritic amphibole syenite.

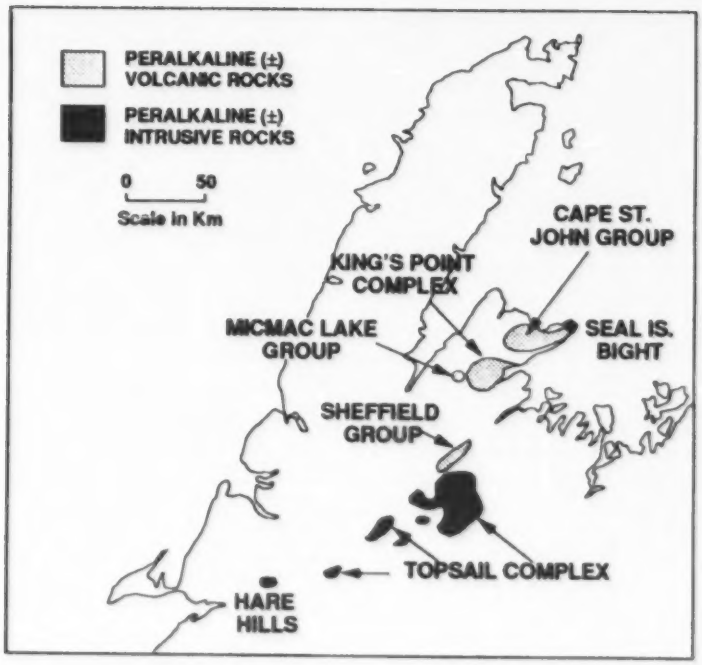

Figure 1. Study area in the Baie Verte peninsula and Topsail area.

Figure 2. Study area in eastern Newfoundland.

Results of this summers work are difficult to evaluate as the quantity of rare metals in most rocks and in particular the fine-grained volcanic rocks is hard to anticipate without the corresponding geochemical results. Work on the Letitia Lake and Strange Lake mineralization indicates that there is a positive correlation between radioactivity, as measured with a spectrometer, and rare metals in an outcrop or sample. This correlation has been applied to the samples collected from the 1990 target areas to give a qualitative idea of the amount of rare metals present; low potential is of no economic interest, medium potential needs further evaluation and high potential indicates values of economic interest. The following is a preliminary evaluation of the target areas:

Kings Point Complex - Several areas of anomalous radioactivity were observed, as well as the occurrence of one highly radioactive pegmatite - aplite vein (<10 cm thick). Pegmatite - aplite veins host mineralization within the Strange Lake deposit.

Cape St. John Group - The volcanics of this group exhibit very low radioactivity and thus are probably low in rare metals. The Cape Brule porphyry is characterized by relatively more anomalous radioactivity and may be the best target for rare metals in these rocks.

Seal Island Bight peralkaline granite - Even though this is a peralkaline granite, the radioactivity is relatively low and suggests low rare-metal contents; pegmatite-aplite veins were not observed in outcrop.

Micmac Lake Group - Low to medium rare-metal potential; very few samples collected.

Bull Arm Formation - The Bull Arm Formation sampling can be broken down into several sample areas due to the large extent of the formation. These are Traytown, Musgravetown, Port Blandford, Plate Cove, Clarenville, Sunnyside, Masters Head and the Doe Hills areas. Areas containing outcrops of medium to high relative radioactivity and thus medium to high rare-metal potential include Musgravetown, Sunnyside and Doe Hills.

Louil Hills peralkaline granite - This peralkaline granite appears to have high potential for rare-metal mineralization as indicated by zones of high spot radioactivity.

Mooring Cove Formation - Mainly low to medium radioactivity (i.e., rare-metal potential) with several units of high radioactivity suggests that several volcanic units within the formation have high rare-metal potential.

Cross Hills Complex - Very high rare-metal potential is indicated by the presence of a large number of small radioactive pegmatite - aplite veins (< 15 cm wide) within a zone of highly radioactive medium grained granite. This setting for rare-metal mineralization is very similar to that at the Strange Lake deposit and thus should be thoroughly evaluated.

St. Lawrence Peralkaline Granite - The overall radioactivity of this granite is very high and suggests that there is a medium to high potential for rare-metal mineralization. Fluorite veins within the granite have very low radioactivity and thus appear to have a low potential for rare-metal mineralization.

Grand Beach Complex - Much of this complex is characterized by low to medium radioactivity which is interpreted to mean low rare-metal potential. Several small areas within the complex exhibit high radioactivity and thus appear to have high potential.

Rocky Ridge Complex - The rocks of this complex have low to medium radioactivity and thus low rare-metal potential.

Winterland Complex - Very rare outcrop has limited the ability to evaluate the rocks of this complex. Radioactivity indicates that the rare-metal potential is low.

Geochemical and other data are required to further evaluate these felsic rocks. Laboratory studies are on-going. Reconnaissance sampling of other targets in insular Newfoundland and some within Labrador will be carried out during the 1991 field season. Follow up sampling and mapping of some of the more encouraging areas from the past seasons sampling may also be carried out next year.

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MINERALIZATION IN WESTERN WHITE BAY

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Mineral Deposits Section

The western White Bay area (Figure 1) hosts three broad styles of mineralization:

i) Structurally controlled mesothermal gold mineralization occurs in the volcanic and sedimentary rocks of the Silurian Sops Arm Group as well as in Upper Proterozoic granitoid rocks and unconformably overlying Eocambrian to Cambrian sediments. Anomalous gold values have also been found within the Murrays Cove schist and Coney Head Complex of the Southern White Bay Allochthon (Figure 1). Mineralization is epigenetic and may be

Figure 1. General geology and tectonic elements of northwestern Newfoundland.

confined to discrete syn- to post-deformational quartz veins (e.g., Browning, Simms Ridge, Unknown Brook and West Corner Brook showings of the Sops Arm Group) or may be more broadly distributed within sheared and pervasively fractured and altered rock (e.g., Rattling Brook occurrence). The gold is associated with sulphides - commonly pyrite and either galena (Sops Arm Group occurrences) or arsenopyrite (Rattling Brook and Murrays Cove Schist occurrences) but generally not both. Alteration minerals associated with these occurrences include carbonate (dolomite, ankerite and siderite), sericite, fuchsite, albite and potassium feldspar. Variable combinations of these minerals pervasively replace wall rock and/or are found in gold-bearing quartz veins at many of the occurrences.

All of these gold occurrences may be related to large-scale hydrothermal activity, which took place during Late Silurian or younger times. Circulating fluids may have been focussed along the Doucers Valley fault complex and subsidary structures; the alteration patterns and mineralization style suggest that deposition took place at depths of several kilometres.

ii) Stratabound galena mineralization occurs in brecciated, altered dolostone of the Lower Volcanic formation at Turners Ridge and Side Pond (Figure 1). Mineralization is found within this unit over a strike length of at least 15 km. At the Turners Ridge deposit, brecciation of the host dolostone is intense and galena mineralization accompanied by calcite and minor barite, silica, pyrite and sphalerite forms the breccia matrix. The calcite has corroded and replaced rims of dolostone fragments. Brecciation, mineralization and calcite alteration are most intense at the Turners Ridge deposit, and not as well-developed at the Side Pond showing to the north, where mineralization is restricted to irregular veinlets. The Deer Lake Basin to the south is a possible source of this mineralization. The tectonically brecciated dolostone may have acted as a structural and chemical trap for upwelling lead-rich basinal fluids.

iii) Minor fluorite and molybdenite are found in the granites and related aplitic dykes of the Gull Lake intrusive suite, which includes the Devils Room Granite, (Figure 1). This mineralization is related to late stage magmatic-hydrothermal activity which took place during the final crystallization of the host plutons.

HEAVY MINERAL SAND EXPLORATION IN THE LAKE MELVILLE AREA

J.R. Meyer and M. Emory-Moore[1]
Mineral Deposits Section

The numerous rivers entering Lake Melville, drain hinterlands underlain by gabbro - anorthosite massifs containing disseminated ilmenite, and granitoid and gneissic rocks that may contain zircon, rutile, and other heavy minerals. Black sand lenses and laminations are known to occur in the extensive post-glacial deltaic, estuarine and littoral sands in the Lake Melville area, and in the coastal zone between Groswater and Sandwich bays. Sand and gravel terraces suggest that previous sea levels were up to 90 m above the present lake level. Reconnaissance sampling of stratigraphic sections, through sand terraces, exposed along the Churchill River road in 1989 indicate that fluvial deposits of the Churchill River contain up to 1 percent TiO_2 over significant thicknesses, and that certain 25- to 40-cm-thick horizons contain up to 4 percent TiO_2. Figure 1 illustrates the study area.

The 1990 field season has attempted to provide a more regional evaluation of the origin, spatial extent and economic value of the heavy mineral sands in the coastal zone of Lake Melville and the Porcupine Strand. Samples were collected from test pits in raised terraces, strand lines, and modern beaches. The nearshore zone was investigated using an Eckman (clamshell) sampler. The observed variations in mineralogy within these depositional facies will be used to formulate a deposition model for placer formation in this and similar geologic settings.

In the study area, the glaciogenic sediments do not exhibit any visible concentrations of heavy minerals. However, they are important secondary sources of placer minerals, particularly where found in association with anorthositic source rocks. The raised fluvial and deltaic terrace sediments are laterally very extensive within the major river valleys and exhibit discrete heavy-mineral laminations throughout. The heavy mineral layers are generally 1- to 5-mm thick and often occur as curved, non-parallel laminations. These sediment suites represent large volume, low grade deposits derived from extensive drainage areas, and are thought to have aggraded rapidly during the rapid Late Wisconsin sea-level regression. Slowing of the sea-level regression, during the last 2,000 years, has allowed localized concentrations of heavy mineral sands to develop. This is particularly evident on the modern river bed where 'pure' black sand lenses up to 5 cm thick are present.

The raised strandline deposits are texturally and mineralogically immature and, although locally enriched, do not appear to be extensively mineralized. These strandline deposits, which can be identified at elevations up to 100 m, generally consist of planar, subhorizontal beds of coarse sand and gravel. The black sands range in abundance from 1 to 4 percent and are commonly associated with lag gravel sequences.

The raised marine sediments are characterized by massive, bioturbated clay. Although they do not hold any placer potential, they will be evaluated for use in ceramics.

The modern beaches, particularly those in open coastal waters, exhibit the highest placer potential. The heavy-mineral sand deposits on the Porcupine Strand are the best example of this, and consist of planar laminations of titaniferous and garnetiferous minerals ranging up to 1 cm in thickness. Five samples, collected

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[1] C-CORE, Memorial University of Newfoundland, St. John's.

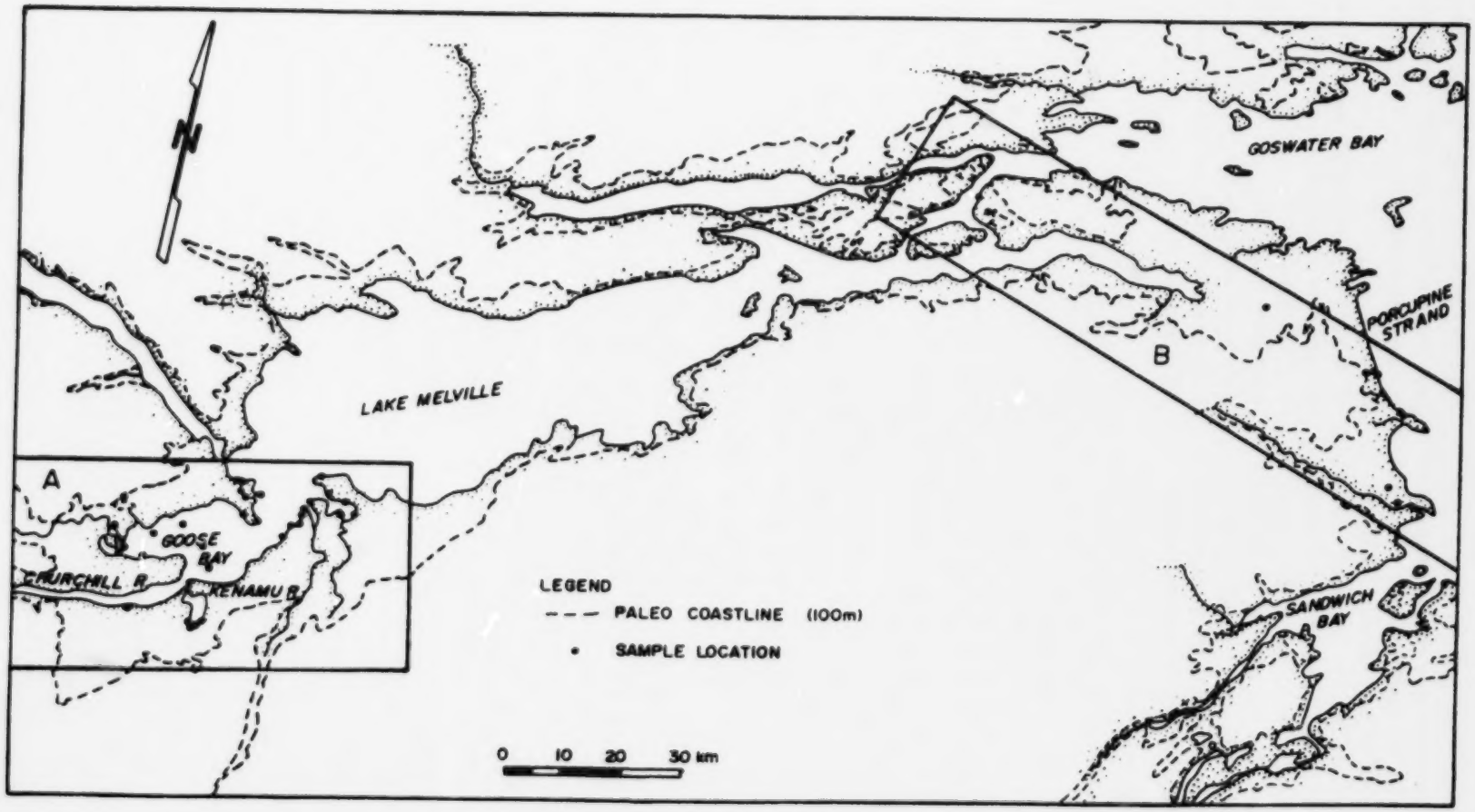

Figure 1. Index map of survey area in the Lake Melville region.

over a distance of 1 km (of the beach) near Beaver Brook, revealed that concentrations of heavy minerals in the supratidal zone average approximately 50 percent over a 100 cm thickness, whereas in the intertidal zone concentrations average 25 percent over a 50 cm thickness. Preliminary estimates of the deposit geometry suggest that the zone of enrichment forms a 3- to 5-m-thick wedge, perhaps up to 25 m in width that is bounded in the backshore and at it's base by a mantle of post-glacial marine mud. The Porcupine Strand is over 20 km long and requires further sampling to establish it's true economic potential.

Six samples of heavy-mineral sand from the area have been submitted to CANMET for a detailed mineralogical analysis and separation into mineral fractions by gravity techniques. Assays for platinum group elements will be carried out, as well as preliminary comments on the economic potential.

GENERAL TOPICS

EARTH-RESOURCES DATA COMPUTER-BASED DIRECTORY

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Database Manager
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Since 1972, the Department of Mines and Energy has accumulated an ever increasing number of Quaternary, geochemical, lithogeochemical, geophysical and resource-based data files. The Quaternary, geochemical, and lithogeochemical files contain field observations and analytical data for a large number of elements. The geophysical files contain field observation data, i.e., gravity, magnetic, gamma-ray and aeromagnetic. The resources based files include the MODS database, the Mineral Claims indices, the drill-core storage and retrieval information, the census and statistics for the Mines of Newfoundland and the geochronological databases for both Newfoundland and Labrador.

Several of the geochemical databases have been compiled and are publically available. These include the lake-sediment data for all of Newfoundland; the lake-sediment data for all of Labrador; granite data for all of Newfoundland; stream-sediment data files for both Newfoundland and Labrador; Quaternary data files for specific areas in Newfoundland and Labrador, and include some granite files for Labrador. A few files, of detailed lake- and stream-sediment data, are also available for Labrador.

A data directory of these databases is currently being prepared for distribution and should be available during the Annual Review of Activities, 1990. This directory will contain an up-to-date list of the major databases currently in use by the Geological Survey Branch and the Mineral Resources Management Branch of the Newfoundland Department of Mines and Energy. Each database is described in detail, and include information such as a list of variables in the database, size, format, availability, and contact person.

This directory will be updated regularly. Future updates will also include digital geology maps of Newfoundland and Labrador and more detailed geochemical, geophysical and lithogeochemical survey information for specific areas. Inquiries about any of these databases should be made to the contact person listed with the database or to the Publication and Information Section of the Department of Mines and Energy.

CORE STORAGE PROGRAM, 1990

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Mineral Lands Division
Mineral Resource Management Branch

INTRODUCTION

In 1979, the Newfoundland Department of Mines started a drill core collection and storage program. The objective of this ongoing program is to provide well maintained and representative collections of drill core from as many drilling programs as possible, for the future use of the mineral exploration industry, government, and university geoscientists and other geotechnical professionals.

This report summarizes activities during 1990 and presents an overview of the operations of the core storage program.

DRILL CORE ACQUISITION

During 1990, drill core acquisition continued in insular Newfoundland and in Labrador and 15,944 m of drill core samples were added to the collection. Most of these core samples, 11,548 m from 136 drill holes, were selected as representative samples from the Nfld Zinc Mines collection at Daniels Harbour which ceased production in 1990. Approximately 1,283 m of core samples from the Mine Brook area, Pilley's Island, were also collected.

In Labrador, 2,257 m from 27 drill holes, were collected from the Kennco Explorations Ltd. 1959 drilling program in the Seal Lake area and are now being stored in the Goose Bay core library, and an additional 857 m of core samples from the Central Mineral belt were added to our collection.

In total, approximately 691,727 m of drill core samples are now being stored.

A catalogue of all open core samples in Department core libraries is available from the Publications and Information Section of the Department of Mines and Energy.

DRILL CORE LIBRARIES

The Department of Mines and Energy now operates six core libraries located at St. John's, Buchans, Springdale, Baie Verte, Pasadena and Goose Bay (Figure 1).

The St. John's library is staffed on a full-time basis except during the field season. It is equipped with a rock saw, a stereomicroscope, a magnetic susceptibility meter, a resistivity meter, an ultraviolet light and a McPhar TV-1 scintillometer.

The Goose Bay core library, which contains core from Labrador, is not staffed on a full-time basis. It has facilities similar to and shares equipment with, the St. John's core library.

The Pasadena core library is also staffed on a full-time basis. This library has equipment similar to the St. John's library along with a ventilated room for storing radioactive core and a humidity-controlled room for storing salt core. The Pasadena building is filled to capacity with only a little working space made free for new core additions by moving some "low priority" core outside the building for continued storage.

The Springdale library is operated by the resident Pasadena geologist from the Pasadena core library, on an appointment basis only. It has a core splitter and a rock saw but shares other geotechnical instruments with the Pasadena core

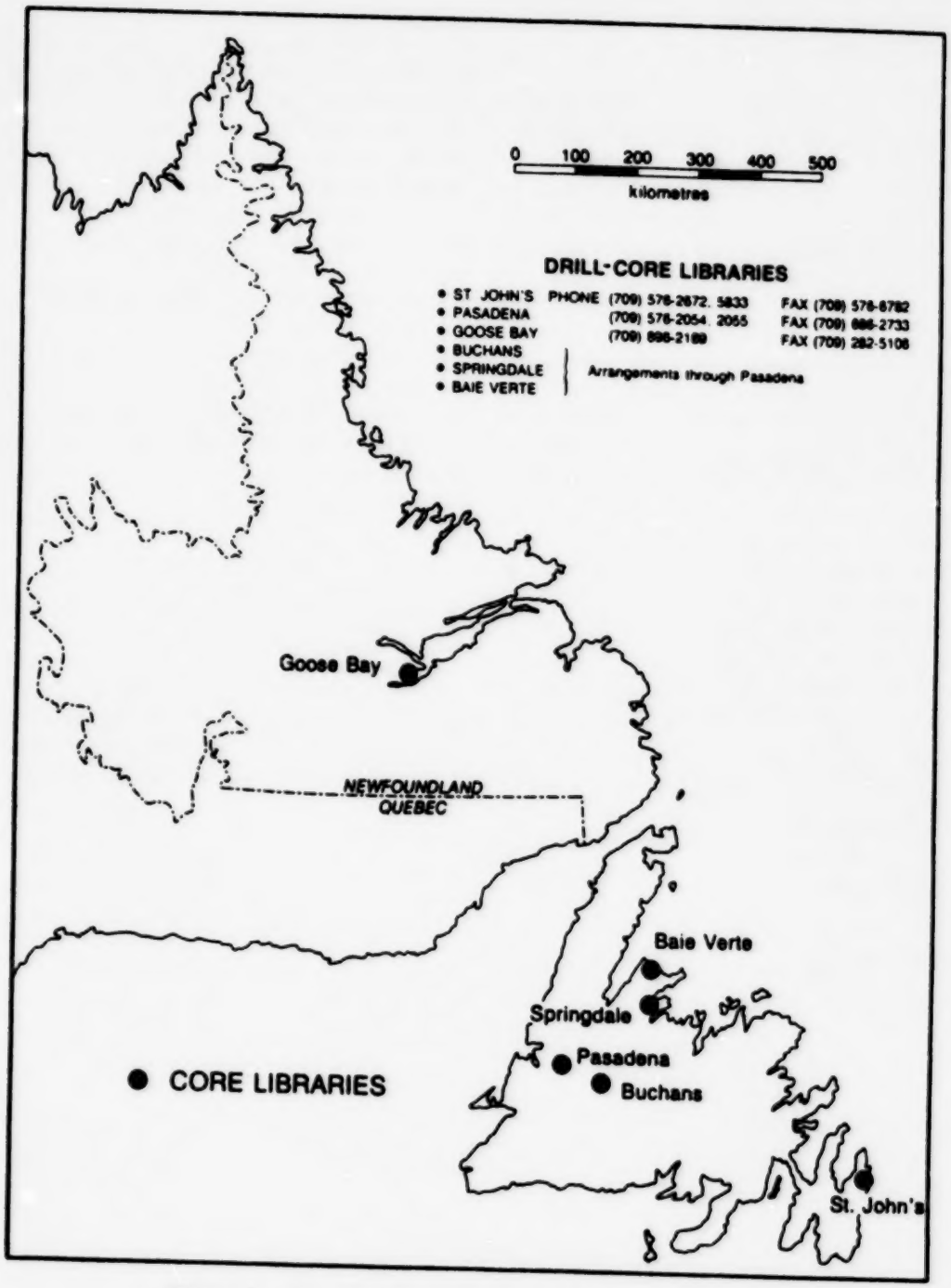

Figure 1. *Core libraries in Newfoundland and Labrador*

library. The extension to the core storage racks in the Springdale building during 1990 will permit storage of additional core samples in the facility this year.

The Buchans core library contains core samples from drilling done by ASARCO and Abitibi-Price during the years these companies were active in mining and mineral exploration in Buchans and surrounding areas. This core library is now fully operational with the completion of an office/core examination area this year but does not have staff assigned to it. The compilation and acquisition of drillhole logs, location maps and other data on core in the Buchans library is in progress. Visits to the Buchans core library are being handled by staff from the Pasadena core library, on an appointment basis. The construction of additional core storage racks in this building is planned for the fall of 1990.

Core storage racks have been installed in the Baie Verte core library giving the facility the capacity to store approximately 4,800 boxes (BQ) of core samples. Renovations to the office area in this building will begin this fall and this facility will be operational as soon as construction is completed. Visits to this core library are also co-ordinated through Pasadena.

CONFIDENTIAL CORE STORAGE

The Department discontinued the practice of confidential storage of industry core samples in November of 1989. All new samples that are added to our core collections are now open and available for inspection by interested parties.

MINERAL OCCURRENCE DATA SYSTEM

C.F. O'Driscoll, J. Smith, G. Stapleton and D. King
Mineral Deposits Section

The Mineral Occurrence Data System (MODS) provides information on the known mineral occurrences in Newfoundland and Labrador. It consists of a manual Mineral Inventory File and a computerized Mineral Index.

The Mineral Inventory File consists of mineral occurrence descriptions that summarize all data on known mineral occurrences in the province. The file presently contains approximately 4000 descriptions, including all mineral occurrences for insular Newfoundland (Figure 1), and selected areas in Labrador (Figure 2). The file and topographic location maps have been microfiched and duplicates are available upon request.

The Mineral Inventory File is presently being updated with new mineral occurrence descriptions. Map areas that have been updated include major parts of 12A, 12B and 12H. In addition, industrial minerals for all of Newfoundland have been documented. An industrial mineral map for the island of Newfoundland is in the final stages of preparation.

Mineral occurrence maps that have updated geological bases have been published at a 1:250,000 scale and are available upon request. In addition, selected areas have been published at 1:50,000 and 1:100,000 scales. These maps contain locations, a listing and a brief description of the occurrences.

The computerized Mineral Index contains information extracted from the Mineral Inventory File, which is stored on a Hewlett Packard 9000/560 Unix-operated mini-computer. The database presently contains information on approximately 3700 mineral occurrences. It will soon be available on floppy disk along with a database program, which enables users to install the database on their personal computers.

An index to all the province's industrial mineral occurrences is also available. This database utilizes IBM compatible REFLEX software stored on a H.P. Vectra ES/12 microcomputer. Users interested in a particular commodity can retrieve a listing of that commodity's occurrences, thus simplifying their search of the manual file.

The manual Mineral Inventory File is used as a quick reference for specific deposits. It is used daily by exploration company personnel and by government geoscientists. The file is available to anyone who is researching mineral deposits in the province.

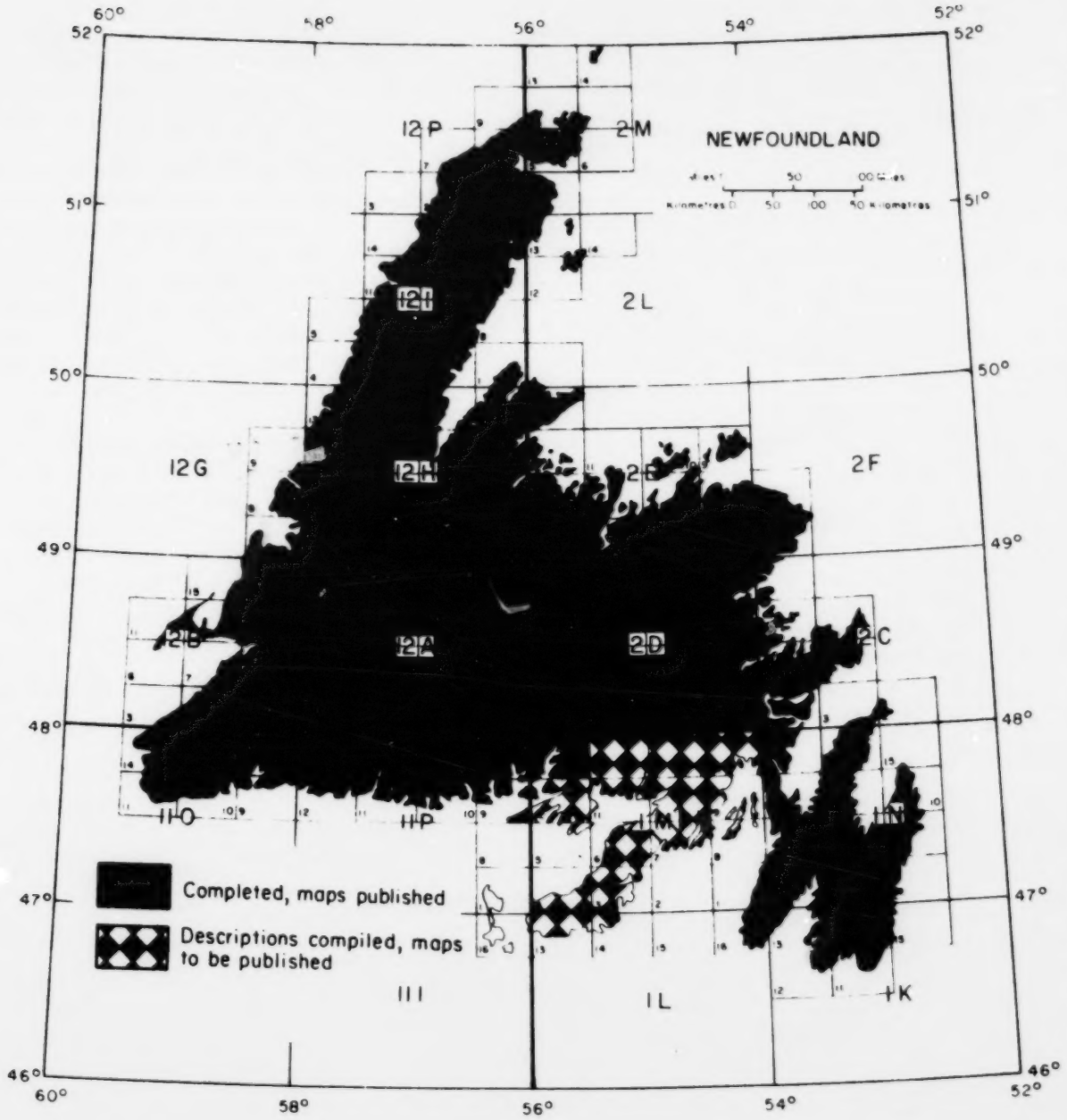

Figure 1. *Index map for Mineral Occurrence Data System project, insular Newfoundland.*

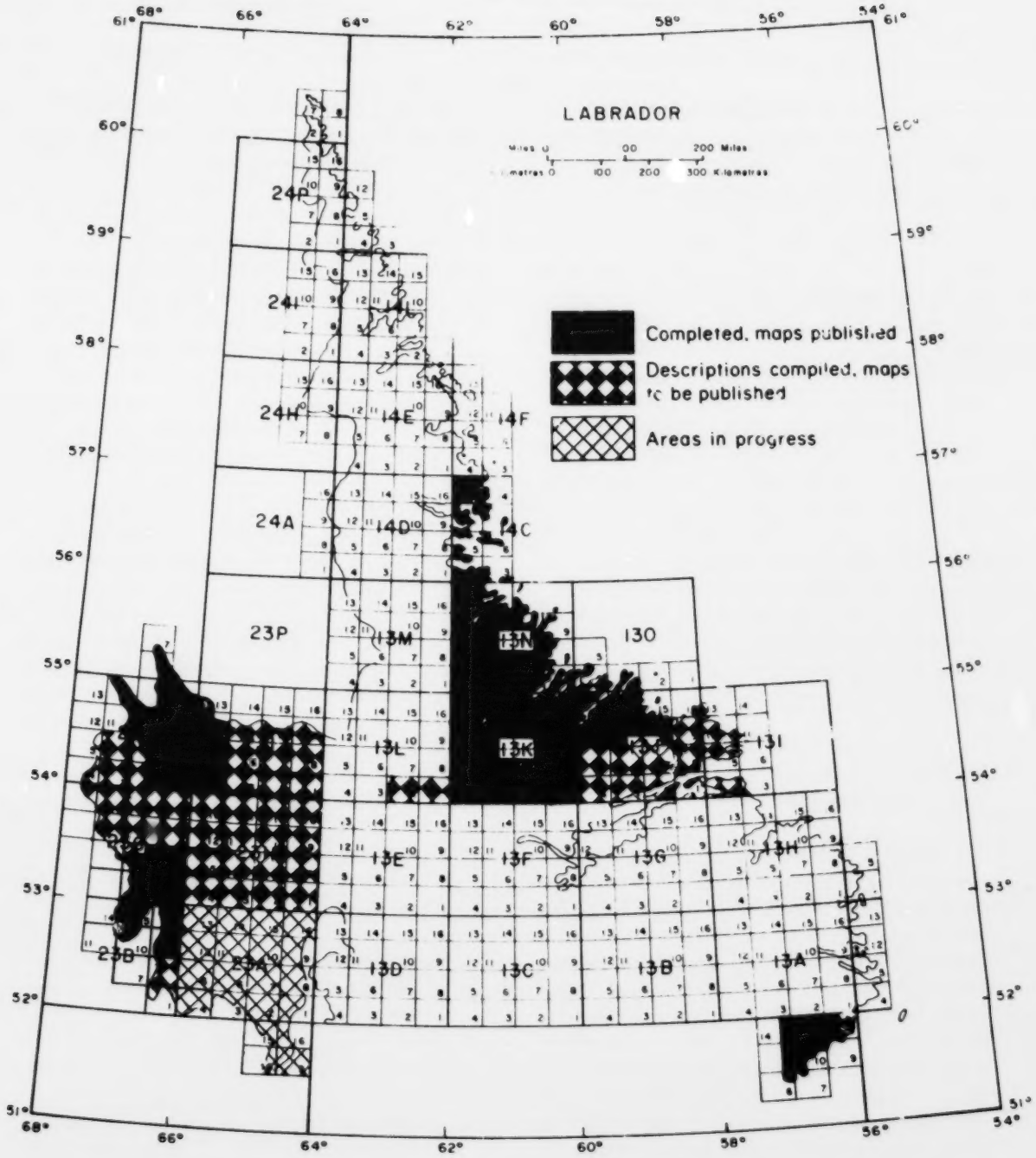

Figure 2. *Index map for Mineral Occurrence Data System project, Labrador*

GEOSCAN - THE NATIONAL DATABASE FOR GEOLOGICAL INFORMATION: THE NEWFOUNDLAND CONTRIBUTION

Catherine Patey and Janet Gillespie
Publications and Information Section

GEOSCAN is a computerized bibliographic database of Canadian produced and/or Canada-related geoscience documents.

The Department of Mines and Energy, Government of Newfoundland and Labrador, is one of sixteen agencies that index documents into this national database. The departmental files, including mineral assessment reports, mineral inventory cards, published reports and maps, university theses, etc. are the sources of the indexed records. Other documents, produced and edited by other agencies, e.g., the Geological Survey of Canada, are the source of other indexed records referring to this province.

Since the conversion of the database in 1982 to the MINISIS software system about 1200 records for mineral assessment files have been added to the database although other types of documents, in particular, those for government publications, have been indexed.

Since May 1990, all new records are batched into GEOSCAN via Datapac and are immediately retrievable, online.

Besides indexing and keying new records, improved keying and editing procedures are being developed with WordPerfect 5.0 macros, and new coding sheets are being produced. The authority files and thesauri used in coding are being enlarged, and all the terms used are being more clearly defined. These terms are maintained on various card files and binders, e.g., company name card file, mineral lands information card file, drillhole information binder. The information on these card files and binders is being transferred to several mini databases on CDS/ISIS and Reflex II software for easier access and reference. These files and mini-databases are to help make indexing consistent and are also useful for in-house inquiries.

As of October, 1990, there were 120,676 records in the database including 9613 referring to this province. The non-confidential records are available through online computer searches at the Geological Survey of Canada Library in Ottawa and at the Publications and Information Section of the Geological Survey Branch in St. John's. Since the demonstration of the search capabilities of the database at the last Open House, the numbers of searches have more than doubled.

References to documents referring to the geoscience of this province are also available from various printed GEOSCAN Newfoundland and Labrador indices:

- Index to documents (including those authored by the Geological Survey of Canada) referring to this province with records in the database up to February 1982.

  -- sorted by NTS - National Topographic System
  -- sorted by Keywords
  -- sorted by Author (both corporate and personal)

- Computer printout to mineral assessment file records entered into the database during the period 1982-1984.

  -- sorted by NTS

- Index to mineral assessment file records received by the Publications and Information Section during the period April 1985 to June 1988 (272 records).

-- sorted by NTS
-- with cross-reference lists by company name, release date, geographic area, local Geofile number.

- Index to mineral assessment file records received by the Publications and Information Section during the period July 1988 to June 1989 (628 records).

  -- sorted by NTS
  -- with cross-referenced lists as above.

A similar NTS index to mineral assessment files, received during the period July 1989 to June 1990 (325 records) will be available this fall.

We welcome suggestions for improvements and appreciate being notified of any errors or discrepancies in the earlier indices. This will aid us in making detailed modifications of the records.

For further information on GEOSCAN, please contact Catherine Patey (709)576-6441.

THE GEOCHEMICAL LABORATORY

H.A. Wagenbauer and P.H. Davenport
Geochemistry and Geophysics Section

The geochemical modelling of geological systems requires accurate, precise and consistent data, and, with the growing sophistication of these models, quality requirements are becoming increasingly stringent. The Geological Survey's geochemical laboratory maintains a rigorous program of quality control based on the routine inclusion of blind duplicate and standard reference materials in all sample sets analyzed. The role of well characterized standard reference materials of various compositions that correspond to the wide range of geological materials submitted for analysis is critical in measuring analytical accuracy quantitatively and objectively. The characterization of these reference materials is the responsibility of all laboratories that employ them, and the geochemical laboratory plays an active role. Over the past three years new reference materials (Table 1) from France, Canada, and the United States have been analyzed for up to 33 elements, and in many cases by several different methods for the same elements. The results from this geochemical laboratory have compared well with those from the best laboratories around the world.

During the 12 months from September 1, 1989 to August 31, 1990, about 10,000 samples were analyzed for from one to more than 30 elements for a total of 155,364 element determinations, a substantial increase in volume of output over the previous year. The total numbers of samples and determinations are only very crude measures of productivity however, as the types of determination vary from single element assays to research-quality major and trace-element analyses of silicate rocks to rapid geochemical analyses of soil, till and drainage sediments (Table 2). A large number of the trace-element digestions were requested by geologists to check older analyses of dubious quality, largely carried out at outside laboratories without adequate quality control.

The geochemical laboratory maintains an archive of powders of all samples submitted for analysis, including those sent to commercial laboratories. These latter samples are prepared in the laboratory, and blind duplicates and reference standards are included in all batches. A computerized analytical request system has been developed, and work is progressing on computerizing analytical data storage and reporting.

Table 1. Characterization of new standard reference materials by the geochemical laboratory.

Agency	Material	Standard ID
GIT-IGW, France	Granite	AC-E
Geological Survey of Canada	Stream sediment	STSD-1
		STSD-2
		STSD-3
		STSD-4
	Till	TILL-1
		TILL-2
		TILL-3
		TILL-4
	Lake sediment	LKSD-1
		LKSD-2
		LKSD-3
		LKSD-4
U. S. Geological Survey	Bottom sediment	BSK-1

Table 2. Summary of output from the geochemical laboratory for the 12 months from September 1, 1989 to August 31, 1990.

ANALYTICAL OUTPUT	samples	determinations
Trace element analyses ($LiBO_4$ fusion) for one or more of Zr, Cr and Ba	2,348	2,648
Trace element analyses (HF-$HClO_4$-HNO_3 digestion) for some or all of Ag, Ba, Be, Cd, Ce, Co, Cr, Cu, Ga, La, Mo, Nb, Ni, Pb, Rb, Sr, V, Th, Y, Zn and Zr	7,069	96,145
Major element analyses ($LiBO_4$ fusions)	3,486	51,505
Trace element analyses of soil, till, sediment	1,203	4,692
Miscellaneous assays (various digestions)	145	374
	TOTAL	155,364